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THE NIAGARA FALLS POWER CO. has recently made contracts that call for the delivery of an output greater than the capacity of two of its 5,000-HP. generators in the central station. The Castner Electrolytic Co., which recently bought out the Mathieson Alkali Works, takes 5,000 E. HP. to manufacture caustic soda and bleaching powder. With the additional power secured this company will use 7,000 E. HP., employ 700 men, and its products will amount to 1,000 tons per week. The Natural Food Co. takes 2,500 E. HP., and is now erecting a six-story steel and brick factory building, 542 ft. long by 66½ ft. wide. The Norton Emery Wheel Co., of Worcester, Mass., has contracted for 1,000 E. HP., and will at once build a factory on the lands of the Power Co. The Niagara Railway Supply Co., with a capital of $500,000, proposes to manufacture the McPherson safety frog and switch and other railway appliances. It has leased a site on the Power Co.'s lands, and will at once proceed to erect its plant. Among the incorporators are De Lancy Rankine, of Niagara Falls, and C. R. Huntley and R. W. Pomeroy, of Buffalo.

THE LOWER RIVER POWER & WATER SUPPLY CO., of Niagara Falls, is now seeking incorporation and a franchise at Albany, with a view to developing power on the lower Niagara River, with a capital of $5,000,000. The incorporators are Commodore P. Vedder, Tunis G. Bergen, Wm. Williams, C. E. Hotchkiss and De Witt V. D. Reily, of New York, and P. F. King, George W. Knox and James S. Simmons, of Niagara Falls. This company proposes to construct a tunnel diagonally across the neck of land between a point at the head of the Whirlpool Rapids, where the river makes a sharp turn to the right, and the Devil's Hole. The tunnel would be about a mile long and be 200 ft. below the surface, with an estimated fall of 90 ft. secured at its outlet. Turbine machinery would be placed in a station at the Devil's Hole, and the water used would there be returned to the river. The rock taken from the tunnel would be dumped into the river and be utilized to strengthen the roadbed of the Niagara Gorge Railway. Electric power would be used for hauling this debris, lighting the tunnel, etc.

THE DEVELOPMENT OF THE WATER POWER of the Rhone is planned by several French syndicates of manufacturers and extensive plants are to be erected within the next three years on the river between Pyrimont and the Swiss frontier. The first of these projects is that of Malpertuis, 2½ miles below Bellegarde, where the river falls 30 to 35 ft., with perpendicular banks only 160 ft. apart. By building a tunnel 1.2 miles long a total fall of 51 to 55 ft. can be secured, equivalent to 25,000 HP. at low water. Near Bellegarde another tunnel would secure a fall of 80 to 85 ft., developing 30,000 HP. And about 8 miles from the Swiss frontier is a narrow gorge only 80 ft. wide, and a dam built here would give a fall of 65 ft., or 30,000 HP. at low water. During nine or ten months in the year these powers would be double the figures given. The power will be utilized for the manufacture of electro-chemical or metallurgical products; or the energy generated may be distributed within a radius of 80 or 90 miles of the works for various purposes.

THE MANUFACTURE OF STEEL BY ELECTRICITY, says U. S. Consul Nelson, of Bergen, Sweden, is being successfully carried out at Gysinge, Sweden; and about 25,000 lbs. of steel ore produced daily in six drafts. This steel is of an excellent quality and finds a ready sale at large profits. Plans have been made to erect a large electric plant for this purpose on the Dalalfuen River, where water power is available.

AN EXPOSITION OF FUEL and heating appliances will be held at Barcelona, Spain, from April 30 to June 29 of this year. A prospectus has been issued from which the following is abstracted:

With the desire of acquainting manufacturers with the natural wealth of the country in regard to fuel, the provincial council of Barcelona will hold an exposition of Spanish mineral coal, including all from anthracite to peat in all their varieties and comprising also patent fuels and waste products, as also pitch and tar, and those mineral bitumens used in the making of patent fuels.

Exhibits will also be admitted of machinery and appliances directly connected with the coal trade, as also of the products derived from that industry; but these will not be competitive.

At the same time, a special exhibition will be held of different systems of hearths, grates, accessories, and other general appliances, whether native or foreign, for more thoroughly utilizing the fuel.

At least two tons of the fuel to be exhibited must be sent, which must faithfully represent the current type and quality obtained in the working.

Intending exhibitors must send applications to the secretary of the "Diputacion Provincial" of Barcelona before March 15 on forms which will be supplied to them, stating the conditions of the fuel and particulars of the mine, or, in the case of an artificial product, particulars of the works must be given. Exhibits must be received by the committee before April 15.

The charges on machinery and appliances connected with the coal trade, and also those on hearths, grates, and other accessories for the use of fuel, must be defrayed by the sender or exhibitor as far as the site of the exposition as also the cost of installation and the return of the exhibit.

Consul-General Lay, of Barcelona, states that he has written the committee to grant American exhibitors the privilege of admitting their applications until April 25 and their exhibits until May 25.

THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred on the Pere Marquette Ry. at Lake, about 60 miles west of Saginaw, Mich., on March 13. A passenger train drawn by two locomotives struck a snow drift, derailing one of the engines and causing the death of two trainmen.

A TRAIN OF OIL-TANK CARS on the Central R. R. of New Jersey parted at Glen Gardner, N. J., on March 24. The rear part of the train left the track and was wrecked and the oil ignited. The latter flowed in a blazing stream through the village, almost wiping it out.

A TORNADO swept over Jones Valley, Ala., in which the city of Birmingham is located, on March 25. A large section of the city of Birmingham and the town of Irondale suffered serious damage, and it is estimated that 13 lives were lost.

A MINE EXPLOSION in the New Klondike coal fields, near Connellsville, Pa., on March 25, resulted in the deaths of nine men.

WATER POLLUTION IN PENNSYLVANIA is to go merrily on, so far as the state legislature is concerned. At least, the House has just defeated, by a vote of 131 to 12, a bill giving the State Board of Health power to protect streams. The bill was approved by the associated health authorities of the state at a meeting held in Harrisburg last January.

THE POLLUTION OF THE PASSAIC RIVER was the cause of a bitter fight during the closing hours of the New Jersey legislature. Bills providing for a sewerage commission with ample authority to construct works had passed the Senate and were practically assured of passage in the Assembly when one of the opponents declared with wicked glee that the legislation would be ineffective, since it had not been advertised in advance, as required by the constitution in the case of all special legislation. A bill was immediately prepared and rushed through the Senate, providing for an advertisement in a Trenton paper the next morning, but this bill was defeated by a narrow majority in the Assembly, through alleged sectional spite on account of certain plank road legislation desired by the people in the lower Passaic valley, but opposed by an adjoining county. There is ample legislative authority for cleaning up the Passaic valley and the State Sewerage Commission has ordered the several offending communities to cease polluting the river by June 1, 1904, but joint action seems to be essential to that end and the communities involved have failed thus far to agree on any steps for the establishment of a sewerage district.

DAMAGES FOR WATER POLLUTION at Elwood, Ind., have been sued for by riparian owners on Duck Creek. The defendants are: The American Tin Plate Co., Wright Shovel Co., Wright Rolling Mill Co., Elwood Iron Works, and Pittsburg Glass Co.

THE METROPOLITAN WATER AND SEWERAGE Board act has been passed by the legislature of Massachusetts and was signed by the governor on March 20. It abolishes the Metropolitan Water Board and the Board of Metropolitan Sewerage Commissioners and transfers their powers and duties to the new commission. As this act took effect upon its passage, the governor immediately made his appointments to the sew board as follows: Hon. Henry H. Sprague, Chairman; Dr. Henry P. Walcott and Hon. James A. Bailey, Jr. The appointments were at once confirmed by the council under a suspension of the rules. Mr. Sprague was the chairman and Dr. Walcott a member of the Metropolitan Water Board, and Mr. Bailey was the chairman of the Board of Metropolitan Sewerage Commissioners. Mr. F. P. Stearns, M. Am. Soc. C. E., has been the chief engineer of the water board since its organization and Mr. Wm. M. Brown, Jr., M. Am. Soc. C. E., has been chief engineer and superintendent of the sewerage commission for a number of years.

THE ESTIMATED COST OF THE LOUISVILLE water filtration plant, the award of contracts for which we noted last week, is $265,525 for a capacity of 37,500,000 a day, or $7,081 per 1,000,000 gallons. It is estimated that this capacity can be doubled for $140,000, which would bring the unit cost down $5,047. The bid of the New York Continental Jewell Filtration Co. was $255,000 for 33 filters of 1,000,000 gallons capacity each, with coagulant devices, but not including connections with the supply, drain and other pipe systems. The estimated cost of the pipe connections is $27,674, which would bring the cost, under this plan, up to $282,674 for a daily capacity of 33,000,000 gallons, or $8,566 per 1,000,000 gallons. The 33 filters would have occupied all the available space in the filter house, whereas the three 12,500,000-gallon rectangular filters, described in our issue of Jan. 17, 1901, and which it is proposed to build, will occupy only half the space. All these calculations are based on a rate of filtration of 125,000,000 per acre per day. The prices do not include the filter house and the clear water reservoir beneath it. The plans on which the contracts are based were made by Mr. Chas. Hermany, M. Am. Soc. C. E., Chief Engineer and Superintendent of the Louisville Water Co. We are indebted to Mr. Hermany for the information given in this note.

BIDS ON A LARGE PUMPING ENGINE CONTRACT will be received on June 18 for the new water-works of Cincinnati, O. The contract will include three 25,000,000-gallon and three 12,000,000-gallon self-contained, vertical, triple-expansion crank-and-flywheel pumping engines. In addition bids are wanted for a boiler equipment for the engines and for a 30-ton electric crane. Mr. Aug. Herrmann is president and Mr. G. Bouscaren, M. Am. Soc. C. E., is chief engineer of the commissioners of water-works.

THE OPERATION OF A PUMP under somewhat novel conditions was recently accomplished at the Revenue No. 1 shaft at Leadville, Colo., according to a press report. When work was closed last year the duplex Snow pump at a depth of 400 ft. was carefully overhauled, check-valves placed in position and the mechanism given a liberal coating of oil. It was expected that with this careful preparation the pump could remain under water for a considerable length of time, and that when operations were to be resumed it would only be necessary to turn on the steam. When steam was raised in the boilers recently the pump was under 80 ft. of water. Although the steam pipe was surrounded by cold water, the steam was turned on and the pump was soon delivering 400 gallons per minute. In two days' time the water had been pumped out down to the pump station and in three days the lowest drift was free of water.

A VACANCY IN THE CORPS OF CIVIL ENGINEERS, U. S. N., is made by the resignation of Mr. E. P. Goodrich, which takes effect on July 31. To fill the vacancy a competitive examination will be held in Washington, D. C., beginning about the middle of June. A circular stating the necessary qualifications and the time and scope of the examination will shortly be issued by the Navy Department, and can be secured by addressing that department. The successful candidate will be a commissioned officer in the U. S. Navy, with the relative rank of Lieutenant, junior grade, and the salary is $2,700 per year to begin with. The last examination to fill vacancies in the corps was held in December, 1900, and from the 14 candidates who then presented themselves two appointments have since been made to fill the vacancies caused by the retirement of Capts. P. C. Asserson and F. C. Prindle, both of whom retire with the rank and three-fourths the pay of a Rear Admiral.

THE AMERICAN BRIDGE CO. is stated to have secured contracts for 20,000 tons of structural material for the steel bridges of the Guayaquil & Quito Railway Co., in Ecuador, South America. The contract was awarded in competition with Scotch and German competitors, and the first shipment is to be made about May 1, and monthly thereafter until all is delivered.

THE SWITCHBACK ARCH BRIDGE OF THE WHITE PASS & YUKON RAILWAY.

The original location of the White Pass & Yukon Ry. reached the highest point of White's Pass, 18 miles out from Skagway, Alaska, by a switchback up the canon at the summit; and on this line the road was operated until this winter, when trains were run over the new steel arch bridge across the canon, commencing early in January. The heavy snows at this point made it desirable to do away with the switchback, and the consequent expense of rotary snow plows and shoveling gangs, so that a new location was made, crossing the gorge by means of a bridge, consisting of viaduct approaches at each end, and a steel arch structure of special design, 400 ft. in length, over the gorge itself.

The only information in the possession of the railway company at the time the decision to put in a bridge at this point was determined upon was a center-line profile. No information of the side slopes was to be had except that they were probably not far from level. Nor was any information obtainable of the possible amount of water to be provided for in the gorge. It was known that any foundation work would necessarily be expensive on account of the very high price of labor. It was also desirable that the total amount of foundation and falsework involved should be reduced to the least possible, owing to the short summer season available for prosecuting it successfully, and the great center-span height. A consideration of these conditions resulted in the adoption of the general design of the structure as built, which turned out to be of less weight than the tower trestle design first considered by the railroad company.

This steel arch, as shown in Fig. 1, consists of two side spans of 80 ft. each, and a central span of 240 ft. The side spans were designed to act as shore, or anchorage arms, during erection, and were anchored down to the concrete shore piers by anchor rods passing through adjusting wedges. The central span was closed by erecting each half as a cantilever to the center, and connecting the structure with a central hinge pin; the entire structure being likewise of pin-connected design. After erection the shore arms were wedged up at the shore ends, so that the side spans acted as simple spans and the central span as a true arch, deflecting much less under live load than it would if allowed to remain as a cantilever with a loose center connection, and throwing the pier reactions nearly normal to the slope of the bank instead of vertical.

The central span supports are concrete abutments carried on solid rock; the end piers are also located in the solid rock of the mountain side, all loose material being first removed, and the foundation pits blasted out into steps, on which was founded the concrete footing courses of the piers and abutments. The concrete is all made with imported Portland cement, in the proportion of one, two and five for the heart work, with a facing worked in, of a one, two and three mixture. Fig. 2 shows details of the skewback masonry for the arch feet.

TABLE I.—Giving Summary of Erection Strains with Truss Load Equal Unity.

Truss name.	Diagram name.	Maximum Cantilever.	Maximum Arch.	Maximum Governing.	Truss name.	Diagram name.	Shore span Fixed.	Shore span Cantilever.	Gov. str.
6—8	K A	+5.04d	+5.04d	+5.04d	6—4	N A	0.00	+5.04d	+5
8—10	G A	+3.36d	+3.78	+3.78	4—2	R A	−0.84	+2.94d	+2
10—11	E A	+1.67d	+3.07	+3.07	e—e	B P, B O	+1.01	−2.03d	+1
11—k	C A	+0.84d	+2.94	+2.94	c—a	B S, B T	+0.67	+0.67d	+0
k—l	B C, B D	−0.67d	+3.35	+3.35	b—b_m	T S	+1.00	+1.00d	+1
l—g	B H, B I	−0.67d	+3.35	+3.35	c—4	R Q	+1.50	+3.75d	+3
g—e	B L, B M	−2.32d	+1.65	+1.65d-l	d—d_m	P O	+1.00	+1.00d	+1
e—6	K N	+7.00d	+3.50	+5.00d-l	e—6	K N	+1.50	+7.00d*	+5
f—f_m	M L	+1.00d	+1.00	+1.00	a—2	A U	+1.50	+1.50d	+1
g—8	J G	+3.00d	+3.00	+3.00	2—1	.....	+2.50	−2.50d	+2
h—h_m	I H	+1.00d	+1.00	+1.00	c—b_m	S R	0.00	−3.78d	−3
i—10	F E	+2.00d	+2.00	+2.00	b_m—2	R U	+0.84	−2.94d	−2
j—11	D C	+1.00d	+1.00	+1.00	a—b_m	T U	−0.84	−0.84d	−0
l—11	D E	−0.84d	−0.84	−0.84	c—d_m	P Q	−0.60	−0.60d	−0
i—h_m	H F	−0.84d	−0.84	−0.84	e—d_m	N O	−1.80	−3.60d	−1
g—f_m	L J	−0.60d	−0.60	−0.60	d_m—4	N Q	−1.20	−3.00d	−1
e—f_m	M K	−3.00d	−3.00	−3.00					
f_m—8	J K	−2.40d	−2.40	−2.40					
g—h_m	I G	−2.52d	−2.52	−2.52					
h_m—10	F G	−1.68d	−1.68	−1.68					

* (6 + 1 local on top.) Note.—d = dead load; l = live load; d-l = dead and live load.

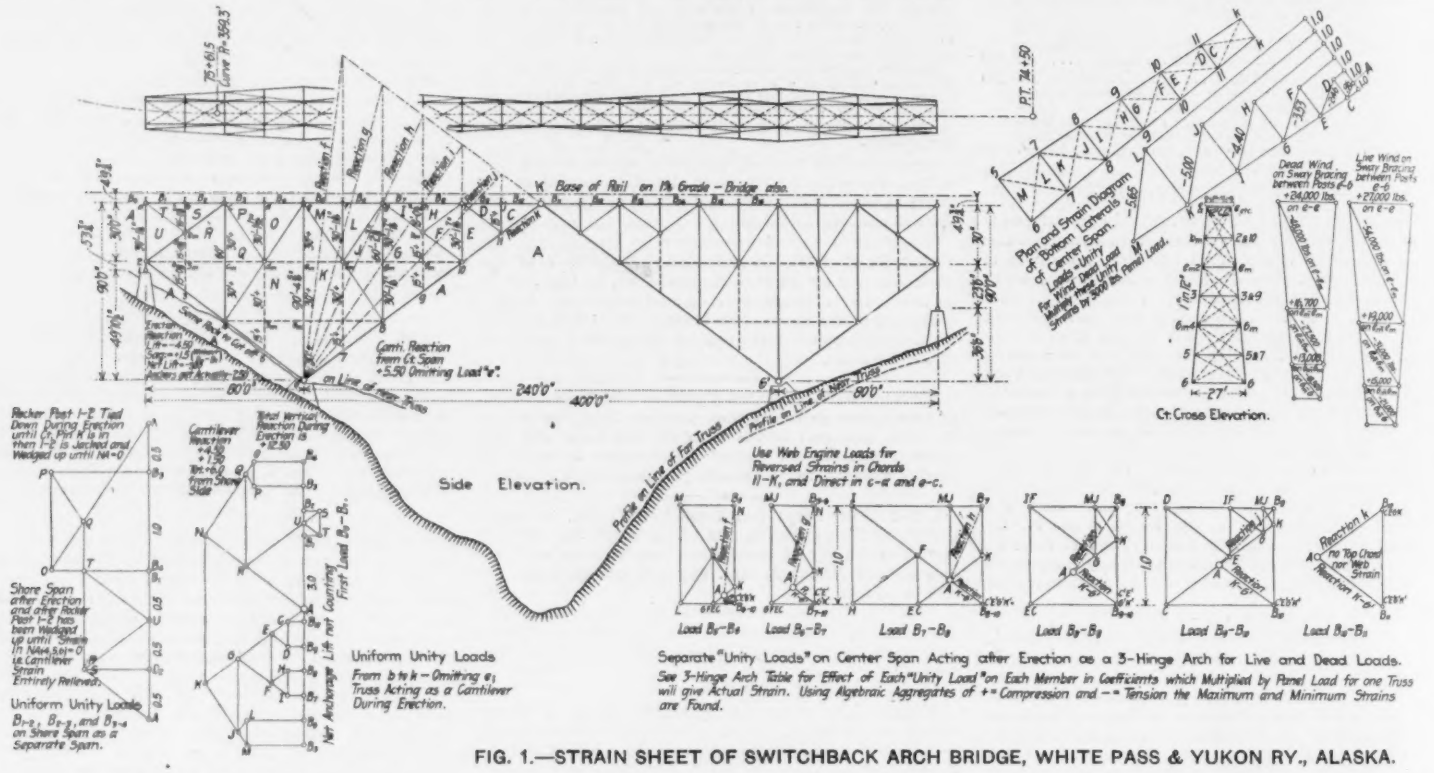
Side Elevation.
Plan and Strain Diagram of Bottom Lateral System.
Ct. Cross Elevation.
Uniform Unity Loads
Separate "Unity Loads" on Center Span Acting after Erection as a 3-Hinge Arch for Live and Dead Loads.

FIG. 1.—STRAIN SHEET OF SWITCHBACK ARCH BRIDGE, WHITE PASS & YUKON RY., ALASKA.

TABLE II.—Showing Arch Effect of Unity Load At

Truss name.	Diagram name.	B_4—B_5	B_5—B_6	B_6—B_7	B_7—B_8	B_8—B_9	B_9—B_{10}	B_{10}—B_{11}	B_{11}—B_{12}	B_{12}—B_{13}	B_{13}—B_{14}	B_{14}—B_{15}	B_{15}—B_{16}	Total +.	Total −.	Load For uniform.	Load Maximum partial.
6—8	K A	.....	+0.14	+0.28	+0.42	+0.56	+0.70	+0.84	+0.70	+0.56	+0.42	+0.28	+0.14	+5.04	0.00	+5.04	+5.04
8—10	G A	.....	−0.14	−0.28	+0.00	+0.29	+0.55	+0.84	+0.70	+0.56	+0.42	+0.28	+0.14	+3.78	−0.42	+3.36	+3.78 / −0.42
10—11	E A	.....	−0.14	−0.28	−0.42	−0.56	+0.13	+0.84	+0.70	+0.56	+0.42	+0.28	+0.14	+3.07	−1.40	+1.67	+3.07 / −1.40
11—k	C A	.....	−0.14	−0.28	−0.42	−0.56	−0.70	+0.84	+0.70	+0.56	+0.42	+0.28	+0.14	+2.94	−2.10	+0.84	+2.94 / −2.10
k—l	B C, B D	.....	+0.22	+0.45	+0.67	+0.89	+1.12	.....	.....	.....	.....	.....	.....	+3.35	0.00	+3.35	+3.35
l—g	B H, B I	.....	+0.23	+0.45	+1.33	+0.89	+0.45	.....	.....	.....	.....	.....	.....	+3.35	0.00	+3.35	+3.35
g—e	B L, B M	.....	+0.55	+0.44	+0.33	+0.22	+0.11	.....	.....	.....	.....	.....	.....	+1.65	0.00	+1.65	+1.65
e—6	K N	+1.00	+0.83	+0.66	+0.50	+0.33	+0.17	.....	.....	.....	.....	.....	.....	+3.50	0.00	+3.50	+3.50
f—f_m	M L	.....	+1.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	+1.00	0.00	+1.00	+1.00
g—8	J G	.....	+0.50	+1.00	+0.75	+0.50	+0.25	.....	.....	.....	.....	.....	.....	+3.00	0.00	+3.00	+3.00
h—h_m	I H	.....	.....	.....	+1.00	.....	.....	.....	.....	.....	.....	.....	.....	+1.00	0.00	+1.00	+1.00
i—10	F E	.....	.....	.....	+0.50	+1.00	+0.50	.....	.....	.....	.....	.....	.....	+2.00	0.00	+2.00	+2.00
j—11	D C	.....	.....	.....	.....	.....	+1.00	.....	.....	.....	.....	.....	.....	+1.00	0.00	+1.00	+1.00
l—11	D E	.....	.....	.....	.....	.....	−0.84	.....	.....	.....	.....	.....	.....	0.00	−0.84	−0.84	−0.84
i—h_m	H F	.....	.....	.....	−0.84	.....	.....	.....	.....	.....	.....	.....	.....	0.00	−0.84	−0.84	−0.84
g—f_m	L J	.....	−0.60	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.00	−0.60	−0.60	−0.60
e—f_m	M K	.....	−1.00	−0.80	−0.60	−0.40	−0.20	.....	.....	.....	.....	.....	.....	0.00	−3.00	−3.00	−3.00
f_m—8	J K	.....	−0.40	−0.80	−0.60	−0.40	−0.20	.....	.....	.....	.....	.....	.....	0.00	−2.40	−2.40	−2.40
g—h_m	I G	.....	.....	.....	−1.26	−0.84	−0.42	.....	.....	.....	.....	.....	.....	0.00	−2.52	−2.52	−2.52
h_m—10	F G	.....	.....	.....	−0.42	−0.84	−0.42	.....	.....	.....	.....	.....	.....	0.00	−1.68	−1.68	−1.68

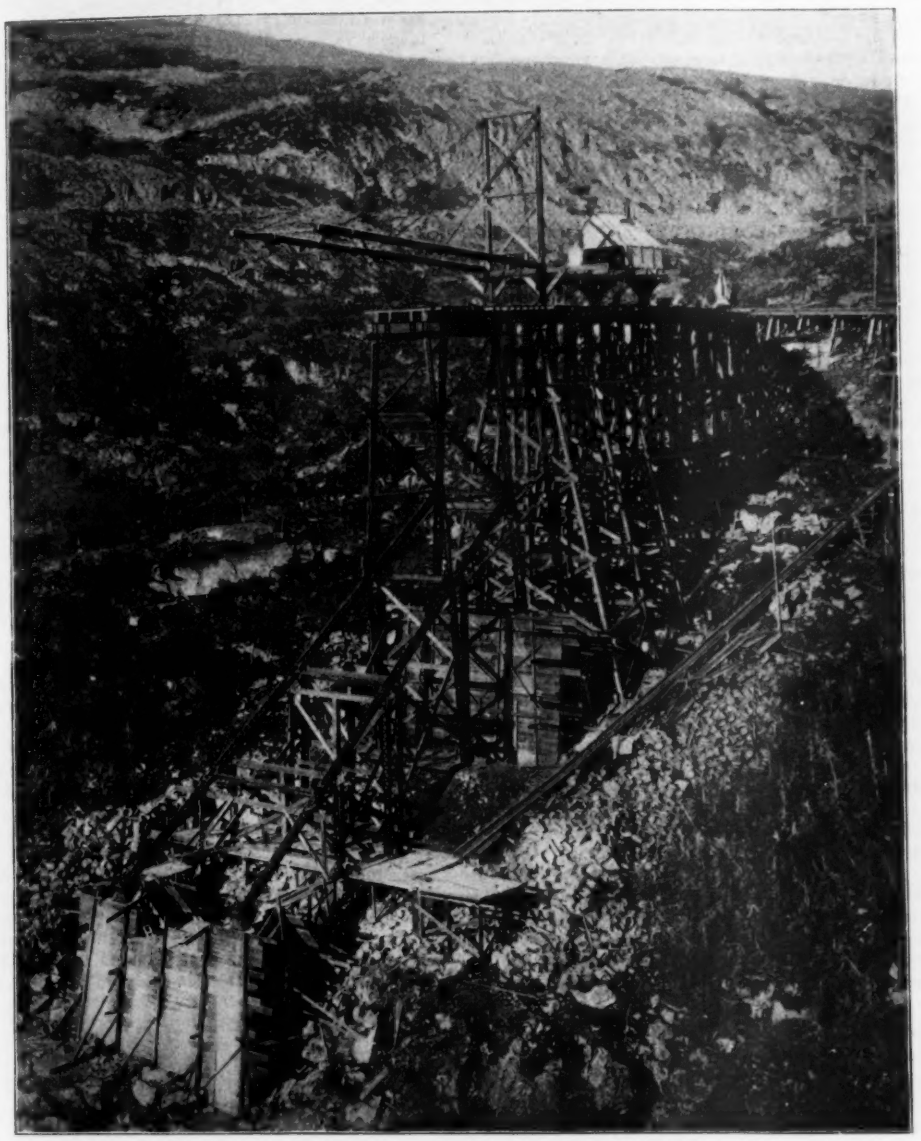

FIG. 3.—VIEW SHOWING APPROACH VIADUCT AND BEGINNING OF ARCH ERECTION, WHITE PASS & YUKON RY. BRIDGE.

Above the foundation pits timber forms were used, into which concrete was placed and tamped; all anchor bolts being set in the concrete work as it progressed.

The superstructure was begun, as shown in Fig. 3, by starting from the end of the approach viaducts, assembling it panel by panel with an overreach traveler of special design, made of materials which would afterwards be of use for other purposes by the railway company; the timbers all being in long lengths, while all of the guys were of wire rope. On the traveler was a four-spool bridge erecting engine, which also acted as a counterweight for holding down the traveler.

The bridge was designed to carry a load in addition to the dead weight of two 96-ton consolidation engines, followed by a train load of 2,700 lbs. per lin ft. The metal work is of medium steel, manufactured in accordance with Theodore Cooper's Specifications for Railway Bridges. The dead load was assumed at 2,000 lbs. per linear foot. Fig. 1 shows the strain diagrams for the various parts of the structure, and Tables I., II. and III. show the nature and amounts of the various strains and the sections adopted to withstand them.

The erection of the bridge was carried on through very stormy weather in the early winter. For many days at a stretch the work could only be carried on for a few hours a day, so that progress was necessarily slow. When one-half of the structure had been erected, it was necessary to take down the traveler, and move it around by the switchback to the other end to continue the work.

When the center of the span was reached, only 20 minutes was occupied in making the last connection, so carefully had the measurements been made in locating the masonry.

Upon the completion of the riveting the bridge was tested by running across it two heavy engines and a heavy rotary snow plow, aggregating in all 270 tons. The maximum deflection under this load, which was somewhat heavier than in the case of the loading for which the bridge was calculated, was ¾-in. at the quarter point of the center span, while the deflection at the center amounted to ½-in. Fig. 4 shows the completed structure.

The anticipated results in being able to keep the road open through the winter were fully realized. In spite of the heavy snows occurring immediately after the completion of the work, it was found very much easier to keep the tracks clear across the summit.

The bridge was designed by the Atlantic, Gulf & Pacific Co., of Park Row Bldg., New York city, Geo. W. Catt, President and Chief Engineer; H. S. Wood, Designing Engineer, and was constructed under the supervision of Mr. Alfred Williams, Resident Engineer for the White Pass & Yukon Ry. Co., of which Mr. E. C. Hawkins, of Seattle, Washington, is General Manager and Chief Engineer. The contractor for the structure was the Puget Sound Bridge & Dredging Co., C. E. Fowler, President and Chief Engineer. We are indebted to him and to Mr. H. S. Wood, the author of the design and calculations, for the information from which this article has been prepared.

HISTORICAL ACCOUNT OF THE TRANS-SIBERIAN RAILWAY.

In "Le Genie Civil," for Dec. 15, Mr. G. de Krivochapkine gives an interesting historical account of the Trans-Siberian Railway and of the influences which brought it into existence and controlled its construction. An abstract of this article follows:

Siberia has formed a part of the Russian Empire practically since the end of the sixteenth century; when a handful of Cossacks, in 1581, crossed the Ural Mountains and attacked the armed bands of the Tartar Khan Koutchoum. The Russians pushed on, and later reached the waters of the Amoor River to the east and the borders of the Frozen Sea on the north, until the Pekin treaty of 1860 recognized Russia's definite possession of the whole Amoor River region and also opened a port upon the Sea of Japan. About 1860 the abolition of serfdom in Russia caused a strong emigration towards Siberia; and the resulting increase in population induced the Emperor Alexan-

TABLE III.—Showing Actual Strains and Sections in Thousands of Pounds and Square Inches.

Member.	Strain Dead.	Live.	Total.	D. unit.	L. unit.	Sections.	Area.
	(+ 58.8)		+ 58.8	+ 14,200			
2—4	— 16.8	— 37.0	— 53.8	— 18,000	— 9,000	2 12-in. Ls, 20-lb., laced, 2¼ ins. × ⅜-in...	12.1
4—6	+ 100.8	0.0	+ 100.8	+ 14,200	.....	2 " " " " " ..	12.1
6—8	+ 100.8	+ 161.3	+ 262.1	+ 14,300	7,150	2 " 40-lb. and cov, 18 ins. × ⅜-in...	30.3
8—10	+ 75.6	+ 121.0	+ 196.6	+ 14,300	7,150	2 " 30-lb. " " 18 ins. × 9/16-in..	23.3
10—11	+ 61.4	+ 98.2	+ 159.6	+ 14,300	7,150	2 " 20½-lb." " " " " .	17.7
		— 78.1	— 19.3*				
11—k	+ 58.8	+ 94.1	+ 152.9	+ 14,300	7,150	2 " 20½-lb." " " " " .	17.7
k—g	+ 67.0	+ 107.2	+ 174.2	15,400	7,700	2 " 35-lb., laced, 2¼ ins. × ⅜-in....	20.6
	(— 46.4)						
g—e	+ 33.0	+ 52.8	+ 85.8	15,400	7,700	2 " 20½-lb. " " " ...	12.1
	(— 40.6)						
e—c	+ 20.2	*+ 44.4	+ 64.6	15,400	7,700	2 " 20½-lb. " " " ...	12.1
c—a	+ 13.4	+ 29.5	+ 42.9	15,400	7,700	2 " 20½-lb. " " " ...	12.1
a—2	+ 30.0	+ 66.0	+ 96.0	12,100	6,050	2 " 25-lb., " " " ...	14.7
	(— 50.0)		— 50.0				
2—1	+ 50.0	+ 107.0	+ 157.0	14,800	7,400	2 " 30-lb., " " " ...	17.7
b—h—j	+ 20.0	+ 44.0	+ 64.0	13,600	6,800	2 8-in. Ls, 13¾-lb., laced, 2 ins. × 5/16-in...	8.1
d and f	+ 20.0	+ 44.0	+ 64.0	10,600	5,300	2 10-in. Ls, 20-lb., laced, 2¼ ins. × ⅜-in.....	11.8
	(+ 75.0)						
c—4	+ 30.0	+ 66.0	+ 96.0	12,100	6,050	2 12-in. Ls, 25-lb., " " "	14.7
e—6	+ 100.0	+ 160.0	+ 260.0	13,000	6,500	2 15-in. Ls, 55-lb., " 2½ ins. × 7/16-in....	32.3
g—8	+ 60.0	+ 120.0	+ 180.0	12,100	6,050	2 12-in. Ls, 40-lb., " 2½ ins. × ⅝-in.....	23.5
i—10	+ 40.0	+ 88.0	+ 128.0	12,100	6,050	2 12-in. Ls, 30-lb., " 2¼ ins. × ⅝-in.....	17.6
	+ 16.8		— 58.8				
b_m—2	— 58.8	+ 37.0	+ 53.8	11,500	5,750	2 10-in. Ls, 20-lb., " " "	11.8
c—b_m	— 75.6	— 37.0†	— 112.6	18,000	9,000	2 10-in. Ls, 20-lb., " " "	11.8
i—11	— 16.8	— 37.0	— 53.8	20,000	10,000	2 Eye-bars, 2½ ins. × 15/16-in.	4.7
i—h_m	— 16.8	— 37.0	— 53.8	20,000	10,000	2 " " "	4.7
a—b_m	— 16.8	— 37.0	— 53.8	20,000	10,000	2 " " "	4.7
c—d_m	— 12.0	— 26.4	— 38.4	20,000	10,000	2 " 2½ ins. × 11/16-in.	3.4
g—f_m	— 12.0	— 26.4	— 38.4	20,000	10,000	2 " " "	3.4
h_m—10	— 33.6	— 66.8	— 100.4	20,000	10,000	2 " 4 ins. × 1 1/16 ins.	8.5
g—h_m	— 50.4	— 103.8	— 154.2	20,000	10,000	2 " 5 ins. × 1¼ ins.	12.5
f_m—8	— 48.0	— 85.2	— 133.2	20,000	10,000	2 " 5 ins. × 1 1/16 ins.	10.6
e—f_m	— 60.0	— 111.6	— 171.6	20,000	10,000	2 " 5 ins. × 1⅜ ins.	13.75
	(— 60.0)						
d_m—4	— 24.0	— 52.8	— 76.8	20,000	10,000	2 " 4 ins. × ⅞-in.	7.0
	(— 72.0)						
e—d_m	— 36.0	— 79.2	— 115.2	20,000	10,000	2 " 5 ins. × 1 in.	10.0
Vrt. struts	Nom.	Nom.	Nom.	.....	.....	4 2½×3½ Ls, 5.5-lb., laced, 12-in., 2 × 5/16 ins..	6.5
Hor. struts	Nom.	Nom.	Nom.	.....	.....	4 2½×3½ Ls, 5.5-lb., laced, 12-in., 2 × 5/16 ins..	6.5

Note.—Dead strains in parenthesis do not combine with live. Dead panel load = 20,000 lbs. for 1 truss; live maximum panel load = 44,000 lbs. for 1 truss on each of two consecutive beams; average live for chords = 32,000 lbs. for 1 truss. *Use web engine loads for maxima in chords e—c, c—a and 11—k. †Possible.

der II. to study various schemes for giving greater value to his immense Asiatic possessions.

The greatest of these was the building of the Trans-Siberian railway; commenced in 1891, at Vladivostock on the Pacific, and in 1892, at Tcheliabinsk, near the European frontier. This line was at first divided into six grand divisions, as follows:

	Km.
Western Siberia; Tcheliabinsk to Obe	1,416
Central Siberia; Obe to Irkoutsk	1,839
Circum-Baikal; Irkoutsk to Missovaia .....307 to	329
Trans-Baikal; Missovaia to Strietensk	1,104
Amoor Section; Strietensk to Khaboroosk	2,214
Oussouri Section; Khabarovsk to Vladivostock	764

The Circum-Baikal line has not yet been constructed, and the Amoor River division has been abandoned; but all the other divisions are now in

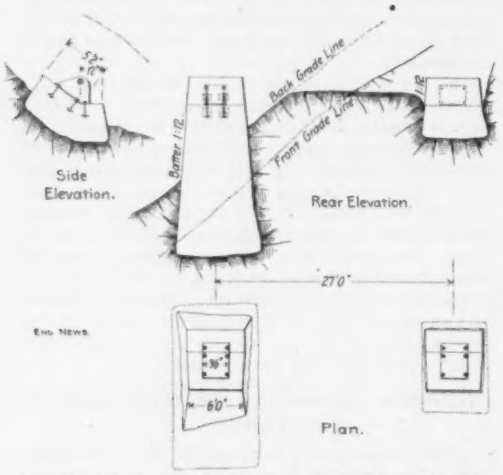

Fig. 2.—Plans and Elevations of Skewback Foundations, White Pass & Yukon Ry. Bridge.

actual operation. The change in the eastern terminus was brought about by the fact that the Amoor River line was difficult of construction and costly; and especially because the treaty of 1896, negotiated between the Chinese government and the Russian-Chinese Bank, opened up to Russia a much more advantageous route to Vladivostock. This Manchurian line is 1,536 km. long, from Nagadene, where it leaves the Russian railway, to Vladivostock, and not including the South Manchurian branch leading to Port Arthur. By this route the total distance from the European frontier, at Tcheliabinsk, to Vladivostock, has been reduced to 6,388 km.; or 6,833 km. to Port Arthur; or about 3,961 miles and 4,238 miles respectively. Of this total 4,300 km., or 2,666 miles are now actually in operation, and the short branch to Strietensk, opened last May, has a purely local interest in shortening to one day the trip down the Amoor River. If we add to the Trans-Siberian railway proper its two Chinese lines, now under construction, the aggregate length of the system is 7,595 km., or about 4,710 miles, including over 2,300 structures in stone or iron.

At the present time it requires about 25 days to travel from Paris to Vladivostock, during the navigable period; this service being assured by the use of a transfer-steamer across Lake Baikal. The rails now used weigh only about 40.8 lbs. per lin. yd., and the roadbed conditions will not permit a speed exceeding 16.5 miles per hour. It is expected that by 1905 this roadbed will be so improved that the time of travel now required can be reduced by one-half.

As to the nature of the country traversed, the western terminus, Tcheliabinsk, is about on the same latitude as Newcastle, in England, though the climate is much more severe. Over the larger part of the Western Siberian Division the cultivation of cereals is greatly developed, especially in the rich districts about Tobolsk; and the raising of cattle is conducted on an enormous scale. The country itself presents a succession of great plains broken by scattered clumps of young trees, with birch trees predominating. There are also many lakes of brackish or sulphurous water; and it is interesting to note that by some geological phenomenon still unexplained, the water in these lakes—though they are often close together, assumes different levels; and some lakes disappear suddenly to reappear again after the lapse of several years.

While the soil of this region is rich, the subsoil, made up entirely of deposits of a recent formation, is devoid of all interest from a mineralogical point of view, at least in the vicinity of the railway line. For all masonry the necessary cut-stone and cement had to be brought from a distance. But in the Altai mountains, gold, iron ore, argentiferous lead, copper and coal are abundant; especially, in the mining district of Semipalatinsk, where the output already demands the construction of a branch railway.

The country is so flat that the grades are very light, and the maximum earthwork amounts to about 23,300 cu. yds. per mile, executed at an average cost of about 10 cts. per cu. yd. Upon this Western Siberian Division there are 274 bridges; the most important of which are the four iron bridges crossing the Tobol, Ichime, Irtich and Obi rivers. The first has a total length of 426.71 m., made up of four spans of 106.68 m. each, of semi-parabolic trusses; the Ichime bridge has a length of 213.36 m., made up of two similar spans; the Irtich bridge is 640 m. long, with six spans; and the Obi bridge is 794.75 m. long, with seven spans, three of which are 148.28 m. long each. These bridges were all built from the plans of Prof. N. A. Belelubsky.

As the lake water is usually brackish and unfit for boiler use, seven artesion well stations have been established, and the water thus obtained is chemically purified. Along with the railway work, extensive drainage operations were inaugurated, which are eventually to affect an area of nearly 11,000,000 acres. This drainage gives value to the marshy lands near Kainsk; and on Jan. 1, 1900, about 875,000 acres were thus reclaimed, by constructing nearly 430 miles of canals and sinking more than 1,000 wells.

In 1898, the Western Siberian Railway carried to the commercial centers of Russia and Europe 393,120 m. tons of merchandise, 280,407 m. tons of grain, and 112,713 m. tons of food products and raw materials. Between 1896 and 1898 over 280,000 emigrants settled upon lands sold to them by the State. Each male emigrant receives 40 acres, and he is released from all import duties for three years, and he can delay payment for the land for three years after his return from military duty. Upon their arrival these emigrants are received in roomy government barracks, supplied with restaurants and hospitals, and under the control of the Department of Emigration; medical care is gratuitous. In this manner, in 1893-99, nearly 13,750,000 acres of good state lands have been distributed to emigrants; principally in the governments of Tomsk, Tobolsk and in Akmolinsk, where the climate nearly approaches that of central Russia.

The Central Siberian Division of the Trans-Siberian Railway traverses a region which is largely mountainous and wooded; and as a consequence 982 bridges of various types were necessary, including structures of wood, masonry and iron. The largest bridge, that over the Yenissei, is 853.42 m. long, and is made up of six semi-parabolic spans, each 144.43 m. long. Owing to the rigor of the climate, the larger part of the masonry in the piers and abutments of these bridges was executed in the winter, inside of shelter-barracks which could be heated. The foundations were also sunk in the winter, by freezing the soil to a slight depth, and then thawing out a lesser depth before excavation, the frozen soil answering as a curbing.

But the greatest difficulty met with by the builders of the line was the "taiga," or almost impracticable virgin forest. This forest rested upon a marshy bed, about 2.3 ft. thick, covered with a strong grass. Here, a wooden railway was first laid down; and then the soil had to be drained by digging a series of ditches. Work in these humid forests was very wearing upon the personnel; especially, as they sometimes extended in an unbroken length for from 27 to 46 miles. Upon this division the grades are heavy in places, and the earthwork averaged about 32,200 cu. yds. per mile, executed at an average cost of 16.5 cts. per cu. yd.

This division traverses an excellent mining country. The high mountains, capped by eternal snow, are thickly covered with virgin forests of great pines and other trees; and the valleys are more or less adapted to the cultivation of cereals, which are largely shipped to Eastern Siberia. In this region the Altai Mountains, called by the Chinese the Mountains of Gold, rise to a mean height of 5,000 ft. above sea-level, with the culminating peak of Bieloukha, attaining a height of nearly 12,000 ft. The Tomsk region has been exploited for its mineral wealth since 1726, and is one of the most important mineral centers of the Russian Empire. The last official report gives the annual gold product at 7,530 lbs.; and in the 124 placer-workings of the Altai region, the value of the sand ranges from 0.54 to 0.80 grammes in gold per metric ton. Silver, lead and copper are found in 800 mines in the Altai district. Iron ore is abundant in different parts of Tomsk, and jaspar, porphyry, agate, marble and breccia are mined in the Busk district. The coal basin of Kousnetsk has a total length of more than 248 miles and a width of about 62 miles, and is remarkable for the thickness of its seams. The coal deposits of Sondjensk are equally worthy of attention for the mass of coal and the excellence of its quality, which is said to approach that of Donetz coal. Chlorate of sodium and Glauber salts are also extracted in great quantities from the lakes in the Barnaoulsk region.

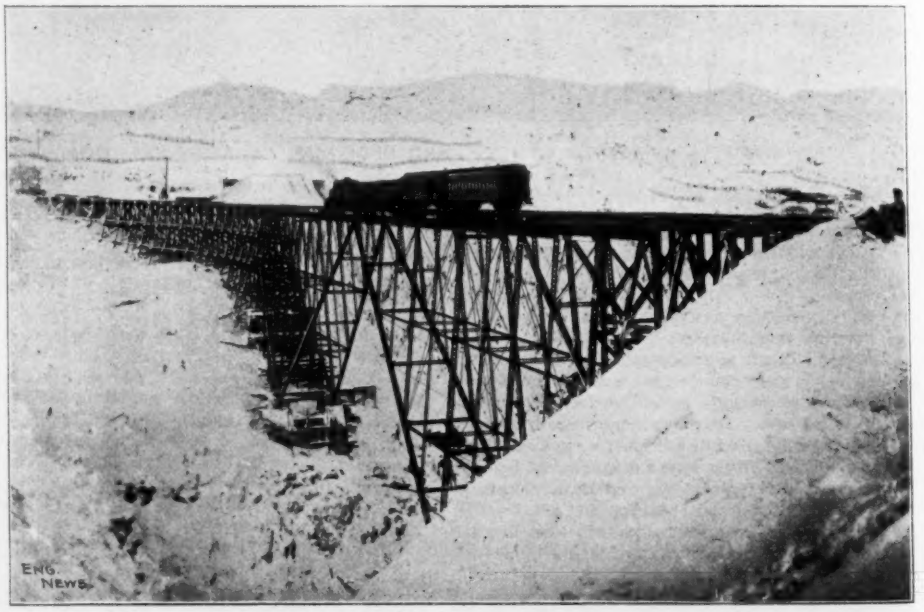

FIG. 4.—GENERAL VIEW OF SWITCHBACK ARCH BRIDGE, WHITE PASS & YUKON RY., ALASKA.

Graphite is found in great abundance in the government of Yenisseisk, this mineral being equal in quality to that of Cumberland and Ceylon. The graphite used in the Faber pencils has been taken from the Irkoutsk district for a long time. There are also indications of petroleum on the river Angara, 26 miles from Irkoutsk.

The Central Siberian Railway, in 1898, carried to Europe and parts of Eastern Siberia a total of 254,560 m. tons. of merchandise, including 54,000 tons of grain sent eastward. In the same year 50,000 emigrants came into this region. The town of Novo Nicoldievsk has a population of 20,000.

The Circum-Baikal Division of the main lines is yet to be built, but communication is maintained between the constructed lines by the establishment of a transfer-steamer service across Lake Baikal; the length of this water transport being 41½ miles. This ice-breaking steamer will carry 25 cars, with their freight and passengers, and during the month of February, 1900, it maintained a speed of from 3½ to 6½ miles per hour through ice 2.8 ft. thick, plus 8 ins. of congealed snow transformed into ice. Another ice-breaker has been built for the transport of passengers only; and a floating dock has been established upon the lake for their repair.

The Trans-Baikal Division was commenced on April 23, 1895, and was completed on May 1, 1900. Of this line about 85% was constructed in a rocky or frozen soil, upon which dynamite alone had any effect. The cold was excessive, touching at times 58° F. below zero in the mountains. The natives took a very small part in the construction, and the larger part was done by State prisoners, who were accustomed to the climate; there was no contract work of any importance, owing to the difficulty of obtaining labor.

At a point 239 miles from the western end of this division there is a branch line, from Kaidalovo to the Chinese frontier, 214.5 miles long. This branch line, resulting from the abandonment of the Amoor River Division, is intended to later connect with the Manchurian railway at Nagadene.

Work was commenced in the summer of 1900 and will probably be finished in 1902, along with the Manchurian railway proper and the branch to Port Arthur. The rail adopted for this branch is heavier than that employed on the main line; it weighs about 55 lbs. per yd. and will permit of increased speed. Upon this branch there are 48 masonry culverts, 103 wooden bridges, and 50 iron bridges.

This Trans-Baikal region is cut by the mountains of Yablonovoi, running southwest and northeast, and reaching in height of 8,200 ft. above sea-level. This country is very rich in minerals, though little actual work has been done in mining. Coal has been found in twenty different localities, having a density of 1.36 to 1.38 and containing from 50 to 53% of volatile matter, 40 to 43% of fixed carbon and 4 to 10% of ash. Gold is found in placer deposits which have been worked for over a century; argentiferous lead mines, near Nertchinsk, have been worked by the government of Russia since 1763; and copper is found in the basins of the Onone and Argougne rivers.

The Khabarovsk-Vladivostock section unites Khabarovsk, on the Amoor River, with Vladivostock, the Pacific port. This line is 473.6 miles long and has upon it 510 culverts, bridges, etc. Work was commenced on May 19, 1891, by the Emperor Nicholas II., when he was Grand Duke; and the line was opened to traffic on Feb. 1, 1896. This railway, a part of the original location of the Trans-Siberian line, traverses an inhospitable and thinly-settled country that has not yet been thoroughly explored for mineral wealth, though coal, iron, lead and copper have been found to some extent. Between 1893 and 1899 about 25,000 emigrants settled in the Oussouri district, under special inducements; and since the inauguration of the Trans-Siberian Railway about 996,000 Russians have emigrated to all Siberia, or an average of 142,000 emigrants per year.

In concluding his article the author remarks that in nine years—1891-1900—the Trans-Siberian Administration has completed 3,348 miles of railway, an average of about 372 miles per year, at a total cost of more than one "milliard de francs," or, say $200,000,000.

THE FOUNDATIONS OF THE NEW MUTUAL LIFE INSURANCE BUILDING, NEW YORK CITY.

By T. Kennard Thomson, M. Am. Soc. C. E.*

GENERAL.

One of the most notable tall building foundations ever constructed is now being carried out for the new building of the Mutual Life Insurance Co., of New York city, which is to occupy the lot extending from the old Mutual Life Building—Nassau and Liberty streets—for 112 ft. 10¾ ins. easterly on Liberty St. and 74 ft. 7½ ins. on Cedar St., thus covering about seven old city lots or 16,000 sq. ft. On Jan. 11, 1900, three sets of plans were drawn up as suggestions for the foundation of the new building. The first of these plans placed the cellar floor on hardpan at an elevation of 55 ft., with 6-ft. side walls of pneumatic caissons carried to elevation 42 to 47 ft., as the only borings made at that time indicated rock or boulders at that elevation. The second plan showed a pile foundation for the Cedar St. building, with the new cellar floor at an elevation of 75 ft., or at water level, and the Liberty St. building on a caisson foundation about 46 ft., with the cellar floor at 55 ft. The third plan indicated a pneumatic foundation for columns, with the entire cellar floor at the level of the water, or 75 ft.

The architects and owners at once decided that while the second and third plans were much cheaper, they did not give enough cellar floor space, and that all the floor space afforded by the first plan could not only be at once utilized, but that its rental value would pay a very large interest on the entire cost of the foundations. The contract was therefore awarded to Messrs. Arthur McMullen & Co., of New York city, on Feb. 5, 1900, for the foundation according to this plan, they having constructed the only similar foundation, that for the Commercial Cable Building, on Broad St., in 1896.

As the existing building had not then been torn down, the intervening time was spent in developing the plans and ordering the material, and a sub-contract was made with F. H. Chapman to haul away and dispose of the material at so much per cubic yard.

UNDERPINNING CEDAR ST. EXTENSION.

The first thing to be done after the old buildings had been removed was to take care of the adjacent buildings, and the first one tackled was the east wall of the old Cedar St. extension of the Mutual Life Building. This was a first-class brick (Portland cement) wall built on a 2-ft. concrete base, 11 ft. wide.

Near the middle of this wall a recess was left for safes on the three lower floors, leaving only an 8-in. brick wall for a length of 8 ft., the upper floors having windows over this recess, which prevented placing the two center underpinning caissons closer together than 14 ft. c. to c. (Fig. 1.) It was decided to support this wall by means of eight pneumatic caissons to be sunk to rock spaced from 6 to 8 ft., c. to c., horizontally except, as stated above, where it was necessary to leave 14 ft. between the two center cylinders on account of not having a solid wall. (Fig. 2.) These caissons were made 36 ins. outside diameter, the metal being 1½ ins. thick, being 3 ins. larger in diameter than the cylinders used by the same firm in 1896 in underpinning the east wall of the Stokes Building, and 6 ins. larger than those used in underpinning the Western Union Building and Stock Exchange in the same year. The greater diameter of course made work in the air chamber vastly easier.

It was decided to allow a fiber strain of about 3,000 lbs. per sq. in., which determined the thickness (1½ ins.) of the metal. Under the Stock Exchange the pressures were from 20 to 42 tons per sq. ft. of base; under the Western Union they were from 30 to 70 tons. Under the Cedar and Liberty St. extension of the Mutual Life Building we had about 36 tons per sq. ft. of base, and under the Stokes Building we had, in the worst case, 56 tons per sq. ft. In figuring these loads on the base the friction on the cylinders, which amounted to about 450 lbs. per sq. ft. of surface, or about 1½ tons per vertical foot, was neglected on the assumption that when we were sinking the caissons the material around the cylinders might be loosened up, reducing the friction to almost nothing. Allowing for friction, the above loads would probably be reduced by about 25%.

In the first cylinders of this kind the cutting-edge section was made of cast iron, as well as the upper portions, but one cylinder struck a boulder while being jacked down, breaking the bottom or cutting-edge section (the diameter was 30 ins. and metal 1 in.), so thereafter the firm always used a bottom 4-ft. section of steel plates, retaining cast iron for the upper sections. Of course cast iron is preferable on account of rust. In this case the cutting-edge section (Fig. 3) was made of two ¾-in. plates, breaking joints, with planed butt joints, but not spliced. The rivets on the outside are all countersunk. A rim angle 3½ × 2½ × ⅝ ins. is placed inside at the top to connect with the flanges of the cast-iron sections. The top of this angle is placed ½-in. below the top of the plates forming a recess or female end into which the upper section fitted, the male projection being ⅜-in., which allowed ⅛-in. play for inaccuracy and to prevent the weight being transferred through the flanges, which were not designed to carry any. The bolts had one side of the head cut, this being preferable to using a wider flange. The upper or cast-iron sections had planed bearing at each end with a flange extending 2½ ins. into the cylinder, in the center of which flange were the holes for the 30 1-in. connecting bolts. Most of the cast-iron sections were made 5 ft. long, but some 2-ft., 3-ft. and 4-ft. sections were ordered to even up at the top. When the shops got behind hand, however, some of the smaller sections were used lower down to avoid delays. Before drawing up the connecting bolts, a 1-32-in. copper wire was placed around the rim as a gasket to ensure an air-tight job.

Between the second and third sections a diaphragm was placed with a door in the center sufficiently large to permit a man to pass through, and two sections above this a similar diaphragm was put in. The space below the bottom diaphragm was the air chamber or working chamber, and the space between the two diaphragms was the air lock, to permit men and material to pass in and out of the air chamber without reducing the air pressure in the air chamber. The cast cylinders above the bottom four merely acted as cofferdams. One 1¼-in. air pipe was used to carry the compressed air down into the air chamber. The planed bearing surface of the cylindrical sections proved to be true enough to hold air with the single fine copper wire gasket.

The bottom of the concrete foundation of this building was at an empirical elevation of 82.5 or 7½ ft. above the elevation of standing ground water. The entire lot had been excavated to within a few inches of the water line, except a bench about 20 ft. wide along the length of this wall. As there was ample space (13 ft. 9 ins.) between the bottom of concrete and the ground floor for working, it was decided to cut eight notches for 15-in. I-beams 6 ft. 6 ins. long, 3 ft. into the wall, so as to place six I-beams side by side, about 11 ft. above the bottom of concrete. When the first notch had been cut out the six beams were put in place as close together as possible, care being taken to have the bottom of the beams on a true level. When the beams had been all leveled up by resting on iron bars at each end, the space between the tops of the beams and the brick wall above was filled with Portland cement mortar (1 to 2), which was compacted by ramming thin pieces of slate into it. In the meantime a notch about 3 ft. 6 ins. wide had been cut from the bottom of these beams to the bottom of the concrete. As this brick work was very hard, the bricks often breaking before the mortar, it was found necessary to use an Ingersoll gadder drill, making lines of 2½-in. holes as close together as possible. At first only two lines were drilled, one on each side of the notch, but the brick work was so hard that it was found advisable to drill several additional lines. While the brick wall was hard to remove, the concrete under it was much harder, and made the work very tedious, especially as it was not considered safe to cut out more than two recesses at a time, and, in fact, not to do much to the third and

*13-21 Park Row, New York city.

fourth holes until the cylinders in the first and second were completed.

On April 25, the top beams being in place, and the brick and concrete underneath having been removed, the first cutting-edge section was put in place, and on April 27 the second cutting-edge section was in position, but it was not until the next day that the first cast-iron section was received. As soon as a section was in place two 12-in. I-beams were placed on top of it to support a 125-ton jack, and as the jack, bearing against the six 15-in. I-beams forced the cylinder into the

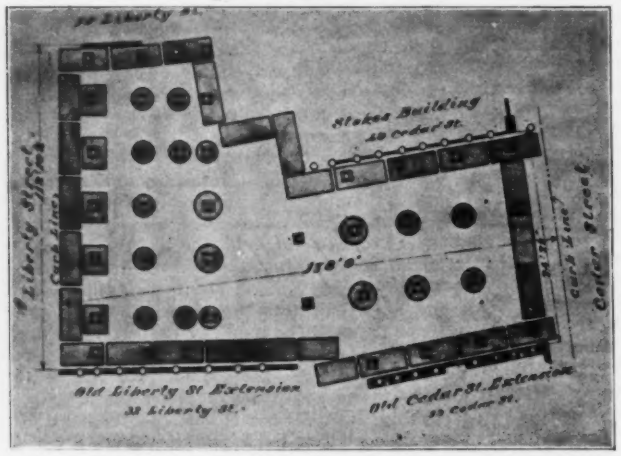

FIG. 1.—FOUNDATION PLAN NEW MUTUAL LIFE BUILDING, NEW YORK CITY.

ground, 12 × 12-in. oak blocks were placed on top of the jack to enable jacking down at least 5 ft. before placing another section. A sand-hog working inside kept removing the material from under the cutting-edge, so that the only force to be overcome by the jacks was the friction on the sides, which was quite enough.

As soon as the cutting-edge section had been forced down, the second section (cast iron) was added, with the diaphragm placed on top. This enabled the men to work in compressed air (keeping the water out), but necessitated letting all the air escape for a few minutes while the sand-hog entered or left the lock or was sending out bags of material, until the cylinder had been forced down far enough to place the second or upper diaphragm. The quicksand was shovelled into canvas bags 7 ins. × 12 ins. × 1½ ft. with ordinary tin

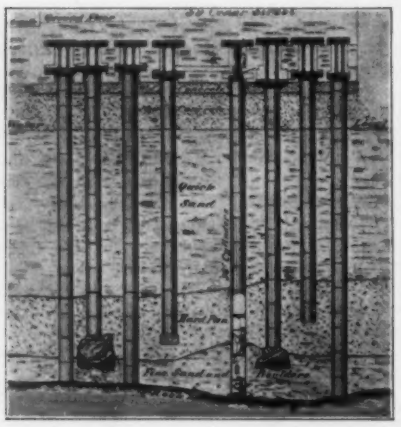

Fig. 2.—Section Showing Underpinning for Cedar St. Extension, Mutual Life Building.

sugar scoops. The only other tools needed were a hammer and points for breaking up the hardpan, boulders, etc.

Cylinder No. 1 was jacked through 42 ft. of quicksand and 10 ft. 6 ins. of hardpan in nine days, being landed on May 11, the delay being caused by the shops not having the cylinders ready. When the cutting-edge had reached the elevation of 32.26 ft., and a hole 3 ft. 9 ins. in diameter had been excavated under the cutting-edge, four jacks aggregating 320 tons nominal (some of the jacks were out of order and were not capable of exerting their nominal force) failed to budge the cylinder, as the sand-hogs had not allowed sufficient room in the hardpan, with the result that the cylinder got jambed. Not wishing to run the risk of either lifting the old building or breaking our jacks, this caisson was at once filled with concrete.

The method adopted in filling all the underpinning caissons was to take the concrete (1 cement, 2 sand, 4 stone) into the air chamber in canvas bags, using four bags at each trip, each bag raising the concrete about 1 in. About 15 mins. were required to lower the bags between 50 and 60 ft. and take the empty bags out, the ramming being done while the bags were in the lock. This operation was continued until the concrete in the air chamber was brought up to the bottom door when hanging open. The sand-hogs then left the caisson and the air pressure was maintained for about 24 hours, when the concrete was sufficiently hard to permit taking air off without drawing water from the cutting-edge. Several times air was taken off after 12 hours, but in each case the water began to come up and air had to be put on again.

The door, pipes, valves, electric light wires and the bottom sections of iron ladders in 6-ft. sections were removed as quickly as possible, and soft concrete was dumped from the top. When

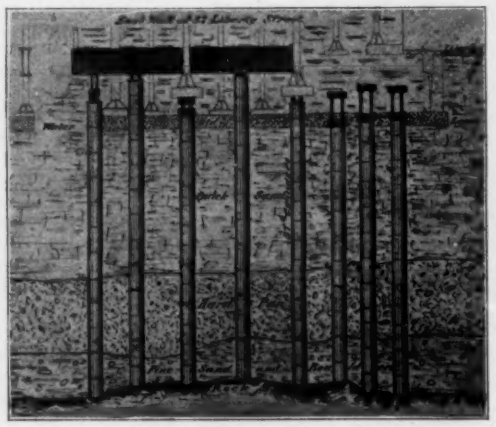

Fig. 5.—Section Showing Underpinning for East Wall of 32 Liberty St.

enough concrete had been dropped to raise the level to the bottom diaphragm, a man was sent down, followed by an inspector, to see that the concrete was compactly rammed under the diaphragm, and this operation was repeated at the second or upper diaphragm, after which the rest of the ladders were removed, and it was found sufficient to lower the electric light wires occasionally to watch the progress. The concrete was brought up in this manner within a few inches of the top of the cast-iron cylinders, and allowed to set for about 24 hours, when it was filled flush with soft mortar and the 38-in. square by [illegible]-in. thick cast-iron cap with a couple of air holes was put in place.

The brick work was then cut out on each side so that five 15-in., 60-lb., × 6-ft. 6-in. beams could be laid on top of the cap. In the meantime the exact distance between this lower set of 15-in. beams and the upper set, which had been placed before the sinking began, had been measured and the vertical 15-in. beams had been cut to length and planed exactly square. Two of these beams

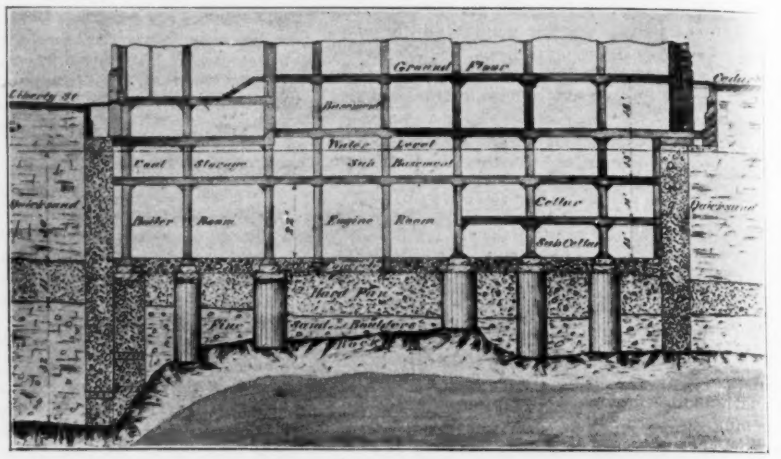

FIG. 8.—LONGITUDINAL SECTION OF NEW MUTUAL LIFE BUILDING FOUNDATIONS.

placed in the rear of the recess, with an 8 × 1-in. plate under them and two 8 × 1½-in. × 1-ft. 6-in. plates over each vertical beam, and between the two 1½-in. plates three pairs of wedges were placed. Each wedge was 2½ ins. wide, ½-in. thick at one end and 1 in. thick at the other by 18 ins. long.

When the two rear I-beams were wedged up, the two front beams were placed directly in front and wedged up so tight that, in the first building underpinned, by the time six caissons were completely wedged, the pressure began to raise the entire wall. As soon as the four vertical beams were wedged up the hole in the wall was completely filled with first-class brick work.

Cylinder No. 2 was started April 27 and finished May 8, making eight working days. When this caisson had penetrated 8 ft. 3½ ins. into the hard-

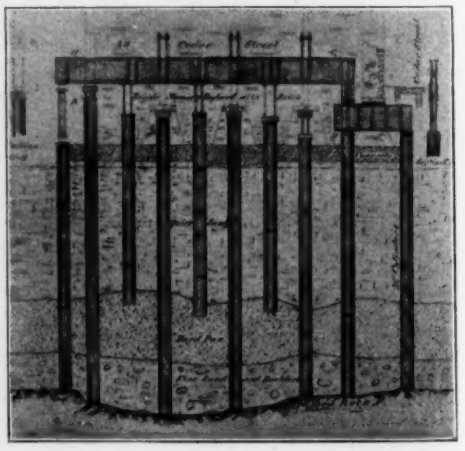

Fig. 4.—Section Showing Underpinning for Stokes Building.

pan it was decided not to sink any farther, as the hardpan was good material.

Cylinder No. 3 was started on May 16 and finished on May 23, or in seven working days; going through 40 ft. of quicksand and 12 ft. of hardpan the cutting-edge struck a very large boulder and the sinking was stopped. It was afterwards found that the boulder was at the very bottom of the hardpan layer.

Cylinder No.4 was commenced May 17 and completed May 26, or in nine working days; passing

through 42 ft. of quicksand and 8 ft. 9 ins. of hardpan, and eventually landing on a boulder, which, when the big caissons were sunk, proved to be 7 ft. deep.

Cylinder No. 5 was begun on May 24 and filled up June 3. This caisson after passing through 39 ft. of quicksand and 15 ft. 7 ins. of hardpan struck a layer of fine sand, boulders and decomposed mica 8 ft. 1 in. thick before reaching the bedrock of New York gneiss.

Before striking this soft stuff under the hardpan it was the intention to stop all the caisson, big and little, near the top of the hardpan, but with this treacherous material on top of the rock it was decided to carry all the permanent caissons to bedrock, although it more than doubled the amount of work originally intended and more than quadrupled the time required, as it took less than two days to put a caisson to hardpan and from 8 to 16 days to get to bedrock. Fortunately the first four caissons which did not go to rock were so placed that the next four came in between in such a way that they would probably carry the entire wall, though without much factor of safety, even provided the first four did not carry anything.

of earth which had been left next to this wall was quickly removed, and the first large caisson put in place.

In all the underpinning caisson work the men worked in three shifts of 8 hours per day, with half an hour off for luncheon, day and night, Sunday included, the only stop being for the Fourth of July. One man worked in the air chamber and one in the lock, while on top one man watched the gage and two handled the block and tackle by which the material was taken out or lowered into the cylinder. The outside men worked 11 hours a day. It is interesting to note that shortly after air was first applied to the underpinning, the east wall of the old Cedar St. building, the air was noticed coming up wherever a hole was dug for the foundations of the Bishop Building on the other side of William St., several hundred feet away, the assumption being that the air was carried through the water bearing fine sand under the hardpan.

UNDERPINNING STOKES BUILDING.

The Mutual Life people were very anxious to complete the Cedar St. end of the building before

sible, and before sinking any caissons for underpinning or other purposes, it was absolutely necessary to bind its various parts together so that jacking against one portion of the building would not break it in two, and the only feasible way to do this was by means of plate girders from one end of the building to the other (Fig. 4).

As the three center columns rested eccentrically on the edge of the brick piers, it was not safe to undermine these piers to place the girders below the granite caps, nor was there room to place the girders between the bases and the street floor, so the only place left was just above the street floor. It was therefore decided to use 6-ft.-deep plate girders, one on each side of the column, with the bottom flange about the level of the first floor. As it was not desirable to run this girder outside of the building line above the sidewalk, the plan of supporting the corner brick pier by independent girders 18 ft. long was adopted.

The general nature of the underpinning as finally carried out is clearly shown by Fig 4. The details of the cylinder caissons and of the methods of sinking were substantially as described for the underpinning of the Cedar St. extension.

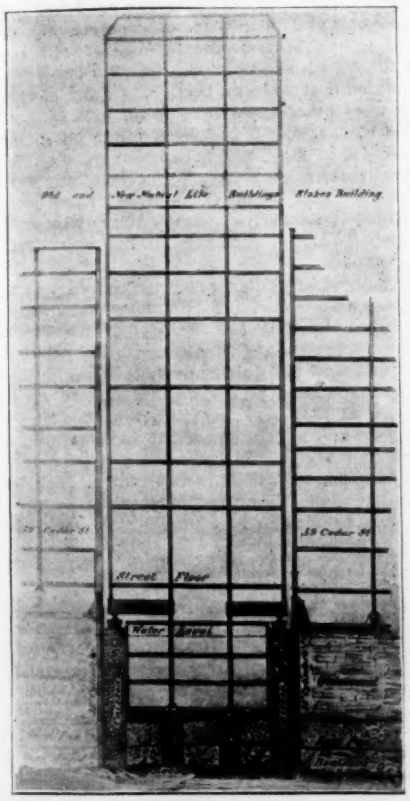

Fig- 6.—Transverse Section of New Mutual Life Building, Near Cedar St. End.

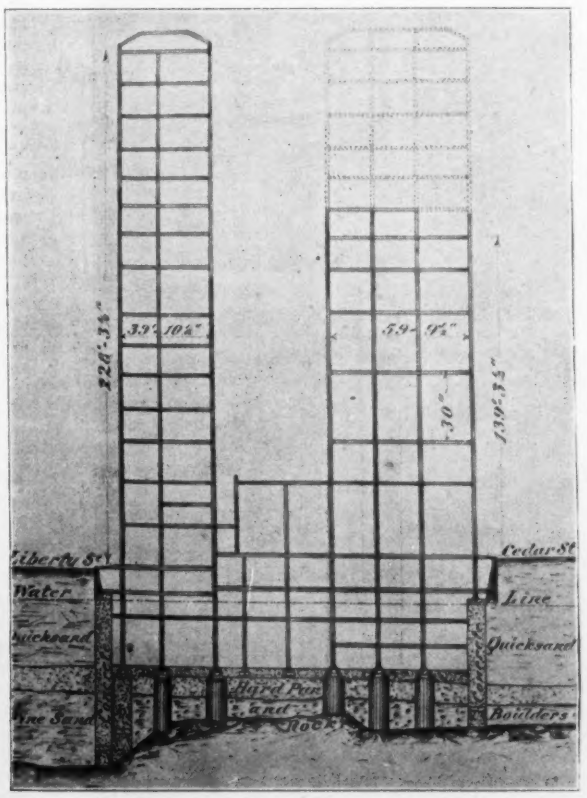

Fig. 7.—Longitudinal Section of New Mutual Life Building, from Cedar to Liberty Streets.

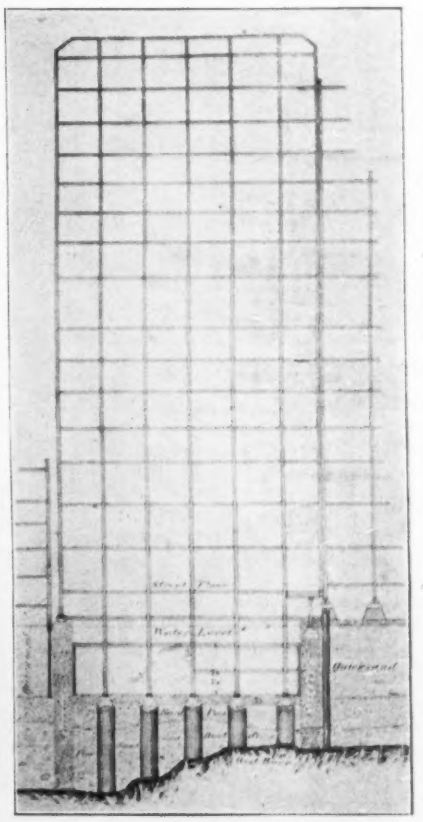

Fig. 9.—Transverse Section of New Mutual Life Building, Near Liberty St.

By this time the sand-hogs had got in the way of leaving plenty of room when going through the hardpan and filling the space 2 ins. or 3 ins. with clay to hold the air better.

Cylinder No. 6 took from May 30 to June 11, or eleven days' work; the material being 40 ft. of quicksand, 12 ft. 7 ins. hardpan and 10 ft. 10 ins. fine sand and small amount of clay, finally landing on a ledge of mica quartz rock.

Cylinder No. 7 occupied from June 4 to June 13, or nine working days, going through 42 ft. of quicksand, 12 ft. 10 ins. hardpan and 5 ft. 5 ins. of fine sand and boulders, finally ending on a bedrock of New York gneiss.

Cylinder No. 8, or the last one put under the first building, ran from June 12 to 21, with practically the same depths of materials as No. 7. It will be remembered that the old foundation of this wall was about 8 ft. higher than some of the other adjacent walls, so as soon as these eight cylinders were completed the wall was undermined between the cylinders and carried down to the water surface by a wall of concrete 3 ft. wide, which also bound the cylinders firmly together. The bench

the Liberty St. extension, but before most of the big caissons at this end of the building could be sunk it was absolutely necessary to secure the west wall of the Stokes Building. This wall was certainly unique in many respects. The corner on Cedar St. consisted of a good brick column all the way to the roof. The northerly corner had a heavy cast-iron column 24 × 28 ins., with 1¾ ins. metal in the basement, first and second floor, above which was brick work. Between the two corners were three cast-iron columns 16 × 15 × 1½ ins. to the roof, all resting on good brick piers, which were vertical on the outside of the Stokes Building but stepped off on the other three sides, making a broad base, but eccentrically loaded. The three center columns rested on heavy granite caps on top of the brick piers, but as the granite had not been properly set, they had all cracked through the middle, probably when the Stokes Building was built. For the first four stories there was an 8-in. brick wall built into the old party wall of very poor brick work, and above this was a good 12-in. brick wall. In short, this wall seemed to be as flimsy and disconnected as pos-

UNDERPINNING EAST WALL OF 32 LIBERTY ST.

At first it looked as if the underpinning of this building would be the most difficult of the lot, owing to the peculiar arrangement of the column bases, for of the nine bases, there were five widely different elevations, and besides five columns were cast square; one was cast round; one was cast rectangular, and two were built up of plates and angles. When, however, the plans were completed and the wall was stripped, showing the best of brick work and first-class iron work, the problem of underpinning proved to be not only simple but safe. This is the highest building which has ever been underpinned, being 18 stories high, and besides on the ground floor were the vaults and safes of a safe deposit company, the officials of which insisted that the settlement of a 1-16-in. would throw their locks out of gear.

By referring to Fig. 5 it will be seen that the two columns nearest to Liberty St. were nearly at the curb level, on very massive brick work, which permitted cutting the notches one at a time, placing the upper beams and jacking down the cyl-

inders, as in the other buildings. The foundation was 2½ ft. of concrete, the bottom of which was at the surface of the water.

The notches for these three cylinders were kept as low as possible, so that the strain from the column above would be distributed over as wide a base as possible while the operation was going on. Working with so small a head room, so near the water surface, necessitated putting a permanent diaphragm on top of the cutting-edge section, which was, as in all the other cases, 4 ft. high. Of course, putting a deck and door four feet from the bottom made slow and clumsy work until the two upper diaphragms were in place, when the bottom door was removed, but all risk of drawing material from under the walls where the superimposed weights were so enormous was avoided. Especial pains were taken on this building not only to get all the cylinders on good solid rock, but also to have nearly the entire cutting-edge bear directly on the rock, and as the rock was generally uneven, and sometimes on edge, so that in blasting more would come out than was required, it was often slow and tedious work to get it level.

The design of these cylinders was similar to that for the other two buildings, except that the metal was 2 ins. thick instead of 1½ ins.; the flanges, etc., being increased in proportion. The inside diameter was the same, making the outside diameter 37 ins., so that if desired a 36-in. diaphragm or cylinder could be fitted to a 37-in., near the top. This was found convenient in several places, owing to the shops not always sending the sections called for, and finally owing to the rock being deeper in some places than others. In spite, however, of the uncertainty of the rock, when the last cylinder was completed, there were no sections left over.

The jacking of the second cylinder from the street occupied from June 10 to 21. Once this cylinder got jammed through the sand-hog not allowing room enough in the hardpan, but by putting on three jacks and working them hard the cylinder was forced through the binding material and afterwards worked easily. So great was the shock when the jacks were released and applied that the ground could easily be felt to shake the platform that carried the traveler, and a shock was also felt in an office on the fifth floor of the building nearly 100 ft. horizontally away from the jack. As it was not safe to do much cutting from cylinder No. 20 until No. 19 had been wedged up, it was July 5 before this one was started, and July 18 when filled with concrete. A similar delay was caused waiting for the hole to be cut for No. 21, which was ready for jacking Aug 6, and concreted Aug. 20.

FIG. 11.—GENERAL VIEW OF BUILDING SITE, SHOWING TRAVELER AND SURROUNDING BUILDINGS.

While the front or heaviest corner of the building was thus being secured by these three caissons, four plate girders had been made and were being bolted on the sides of the cast columns and to the flange angles of the built-up steel columns The depth of these girders was made 5 ft., being the greatest depth that could be used, so as to clear the cast shoes of the columns and keep below the beams of the ground floor. The arrangement of these girders and of the supporting cylinders is clearly shown by Fig. 5.

UNDERPINNING 16 LIBERTY ST.

The only remaining wall to be taken care of also belonged to the Stokes's, being a six-story building on Liberty St. Here it was considered sufficient to sink four cylinders of 16-in. wrought-iron pipe, weighing 45.2 lbs. per ft.; these pipes came in various lengths, from 4 to 7 ft., with a cutting-edge section formed by cutting a coupling in two and screwing it on. Another half of a coupling was used at the top for jacking against.

The cylinders were put down by using a jet, made of a ¾-in. gas pipe, to which fresh lengths were coupled as the cylinder went down, and a 60-ton hydraulic jack, care being taken not to lift the building.

The first operation consisted of burying three 15-in., 60-lb., × 4-ft. I-beams in the wall just below the street floor line. These beams were placed as close together as possible, and bedded into the wall, pieces of slate being used to pack the mortar on top. A 24-in. slot was cut from this down to the ground through a very poor rubble masonry cellar wall, when the pipe was put in place and jacked to hardpan, section by section. The sand was then pumped out and 5 or 6 ft. of concrete was deposited in the bottom, the balance of the pipe being filled with sand and capped with two 1½-in. steel plates that were on the job. On top of these plates were placed two 18 × 20-in. × 12-in. thick granite blocks, which had been taken out of one of the old buildings, and between the stones were placed three sets of wedges. The remaining space between the stones and the bottom of the beams was filled with brick work, after which the wedges were driven until the building was lifted a hair's width.

This method of underpinning, of course, was not nearly so reliable as the pneumatic process, for there was always a chance of stopping on a boulder in the quicksand, but the superimposed loads were very small and the quicksand here is remarkably free from boulders. We were thus able to get the cylinders all down to hardpan, and the support given was ample to support the old building, although the big caissons went down over 40 ft. below the bottoms of these cylinders. The best idea of the necessity of underpinning the adjacent walls can be obtained by glancing at the cross-sections, Figs. 6, 7 and 8.

SHEET PILING.

As soon as the old buildings had been removed in April, the old area walls were torn down and replaced by 3-in. sheet piling 26 ft. long, the water line being about 20 feet below the street level. About 95 lin. ft. of this sheeting was driven on the Cedar St. end. The sheeting was supported by three lines of horizontal waling pieces, 12 × 12 ins., the two upper lines of which were supported by three inclined struts each, making an angle of about 45°. The ends were, of course, braced against the old building. Similar sheeting was driven along Liberty St., but here the vertical length was only 20 ft., and the horizontal length about 115 ft.

It was the intention to drive a line of 9-in. Wakefield sheet piling to hardpan at Cedar and Liberty streets to avoid risk of causing a caving-in of the streets, and the driving was started at the westerly end of the lot on Liberty St. It was found, however, that driving this piling was doing more damage than could be done by the caissons themselves, especially to the 6-story building 16 Liberty St., which, being built on the elastic quicksand, was pretty badly shaken, although no serious damage was done to it. Before driving, a gas-pipe jet was shoved down in the groove, but even with this the driving was hard, with the results as stated. In fact, any kind of pile if driven at all hard seems to disturb light buildings on quicksand more than sinking caissons, unless the latter are too close.

STAGING PILES.

A 44-ft. pile driver was built between April 23 and May 8. This driver was used for driving all the temporary piles. Afterwards the side braces were stripped off and the machine was used for driving clay in the joints. In all 95 piles were driven

to hardpan to carry the temporary trestle, and 20 more to support the compressors. These piles were put in as required, care being taken to locate each pile, so that it would not interfere with the sinking of any caisson.

A temporary trestle was built to carry the traveler and a platform on the Cedar St. level. The runway for the traveler, 60-lb. rails, was 20 ft. center to center, and so arranged that there was a vertical post and pile directly under the rail every 6 or 7 ft., so placed that the sinking of the caissons did not disturb these posts. The heaviest caissons were about 17 tons, and were handled by a single boom of the traveler. The platform was made heavy enough to set the heaviest caisson down anywhere, and was kept heavily loaded with caissons, cofferdam stone, sand and barrels of cement. As lifting 15 tons by one boom had the tendency to lift the traveler, it was always anchored to the rail with four pairs of steel clamps before hoisting; the rails being bolted to the stringers, the stringers to the caps, the caps to the sills, the sills to the sub or longitudinal sills, and the latter to the piles.

Of course a platform and traveler of this kind are expensive, but after once up the cost of handling the material is reduced to a minimum, and besides the available working space was almost doubled, the space underneath being fully taken up by the compressors, sand-hog house and storage of cylinders, clay, etc., etc., leaving the top for mixing concrete and handling material.

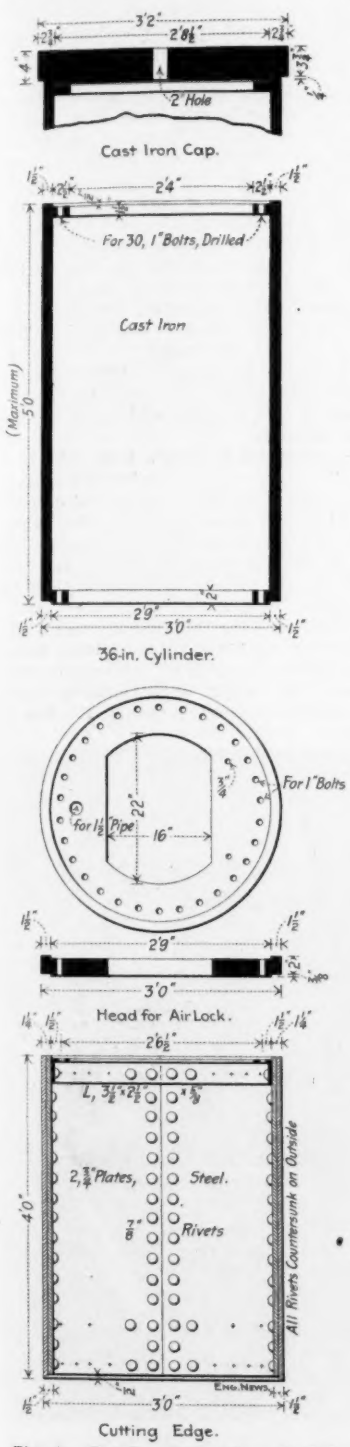

Fig. 3.—Details of Cast-Iron Cylinder Caissons with Steel Cutting Edge for Underpinning Work.

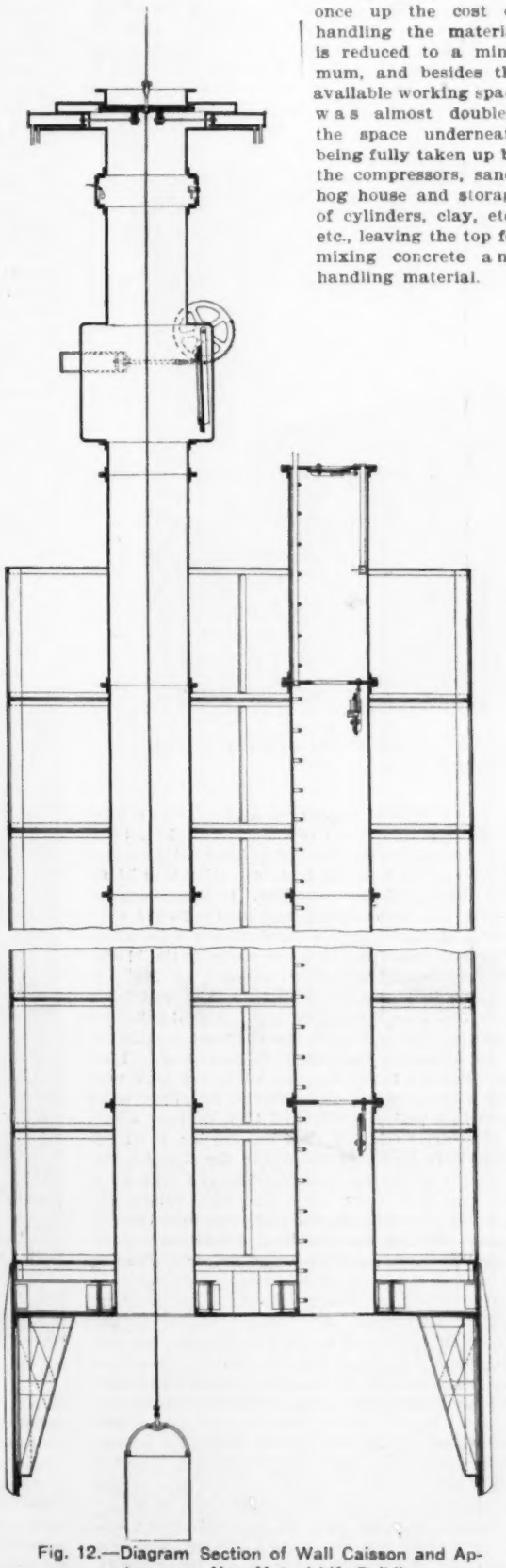

Fig. 12.—Diagram Section of Wall Caisson and Appurtenances, New Mutual Life Building.

NATURE OF THE GROUND.

The old cellars were on quicksand at or a few feet above the water level, which material continued to hardpan, which was from 30 to 35 ft. below the water line. This was a very fine sand, with more or less red clay in it at different elevations. Above water this material would stand vertically for perhaps 5 or 6 ft., but the slightest application of water would wash the whole bank away; in fact, it flows almost as freely as water when wet. There were practically no boulders above the hardpan. The hardpan, which varied in thickness from 8 to 15 ft., was very compact and difficult to remove with a pick; in some places there were no large boulders and in other parts of the lot there would be almost a solid mass of boulders. In two cases there appeared to be hollow spaces in the hardpan of 2 to 3 ft. capacity, with absolutely nothing in them unless air.

While the material above the bottom of the hardpan was very uniform, the material below was exactly the reverse. At one point there was absolutely nothing between the hardpan and rock, while in other places there was from a few feet to 32 ft. of fine sand, boulders and decomposed mica rock that could be cut with a knife. Some caissons struck nothing but fine sand, while others went through a little of everything. Along the east side near Liberty St. there were ten feet or more of a clayey matter like decomposed micaceous rock, with a large amount of iron pyrites, which could be cut with a knife, but was very hard to remove, as a pick would only break out a small chunk at a time. In nearly all cases the bed-rock was what is known as New York gneiss, with a horizontal stratification in some places and inclined or vertical in others. In one place on the west side, near Liberty St., there was considerable quartz, while mica was found more or less all over. In one caisson the rock was about 12 ft. higher at one end than at the other.

CAISSONS.

A wall of 30 rectangular caissons, 8 ft. wide, was placed around the lot as close together as possible, of four different lengths, viz.: 8 ft. × 18 ft.; 8 ft. × 17 ft. 3 ins.; 8 ft. × 22 ft., and 8 ft. × 15 ft. 6 ins. All of these caissons had a ladder shaft and an excavating shaft, each of 3 ft. inside diameter The ladder shaft had a cast-iron diaphragm 8 ft. from the deck, to which a door was attached for use when changing the lock. On the top of this shaft was a lock made of an 8-ft. 1-in. section of shaft with a cast-iron diaphragm top and bottom, and to prevent using long bolts every time the lock was changed to add more shafting, a 12-in. section of 3-ft. shafting was bolted on to the bottom of the lock. The excavating shaft had a heavy iron door hung from the deck of the caisson, with a hinge in the middle so that the door could either be doubled up or taken apart and put in the bucket and sent out before filling the caisson with concrete (Fig. 11).

On top of the excavating shaft was a Moran lock; the bottom door in one piece hanging in enlarged shaft when open and the top door in two pieces, sliding on horizontal runners. This lock was operated by compressed air and required a pressure of about 40 lbs. per sq. in. to shut the doors, and the air pressure was therefore kept up to this pressure in the receivers.

As it was essential to sink these caissons as close together as possible, and yet leave room enough to put the stock-ramming pipe between the ends, two 6 × 4 × ⅝-in. × 9-ft. angles were placed on each end of each caisson in such a way that the caissons could be all alike and yet fit into each. This made the minimum distance between the caissons 4 ins., barely enough to let the pipe through.

On top of the caissons were bolted cofferdams. As the cofferdams did not have any angles corresponding to the separating angles on the caissons, 6 × 4-in. oak strips in about 15 ft. lengths were bolted to the caisson, close up to the steel angles, and continued up to the top of the cofferdam, using two bolts to every 5 ft. of cofferdam and making an ordinary scarf joint. Of course, these timbers were only put on the free end of the caisson, as the other end of the caisson was guided by the timbers on the caisson already sunk. These timbers or skates answered fairly well, but steel angles all the way up would be better. In a few cases the caisson caught on to the skates and tore the bolts out, carrying the skate on down, while in one case a caisson got slightly out of plumb, cut through the skate, and caught up on top of

the steel angle of the adjoining caisson, and also, against one of the underpinning 36-in. cylinders, but fortunately it was in exceptionally good ground, so that we were able to excavate to bedrock, 14 ft. below the cutting-edge of the caisson, and fill with concrete without any trouble. In most parts of the lot, however, such an occurrence would have given a great deal of trouble, as water flowed so freely in the sand under the hardpan in some places that it was very difficult to keep it out of the caisson.

The circular caissons and cofferdams were all made of ⅝-in. plates, the air chamber being, as in all the other large caissons, 7 ft. high, with the

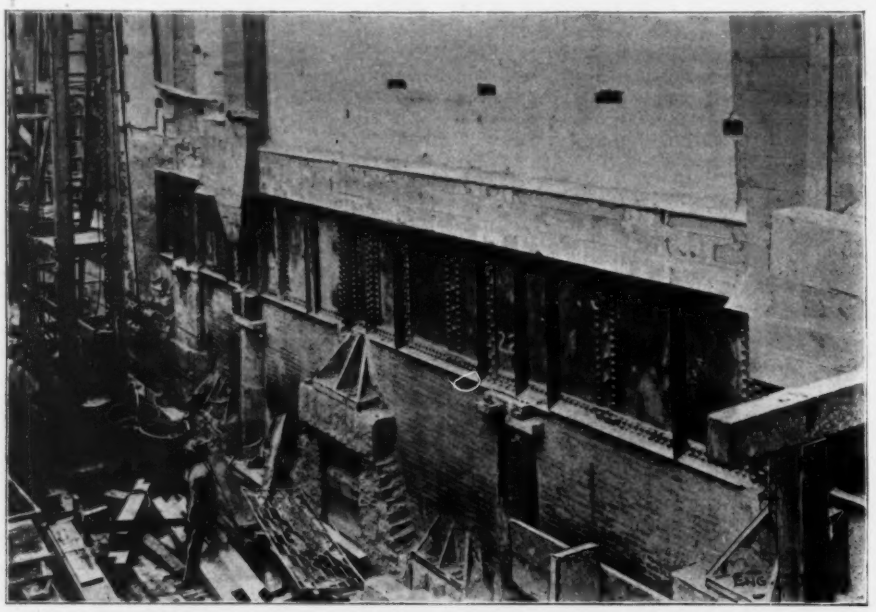

FIG. 10.—VIEW SHOWING UNDERPINNING GIRDER FOR EAST WALL OF 32 LIBERTY ST., NEW MUTUAL LIFE BUILDING.

caisson extending 2 ft. above the deck or roof—which was made of flanged plates, with the flanges up.

The interior caissons, 18 circular and five rectangular in number, had only one shaft on account of being so small, and because the excavating lock weighed about seven tons, while the man lock weighs very much less, with the result that both locks on a small caisson would cause eccentric loads while sinking, making it very difficult to keep the caissons plumb.

The cofferdams for the circular caissons were shipped in half circles, 12 ft. 6 ins. high, made out of two ⅜-in. plates, each with 6 × ⅜-in. connection plates. The object in shipping them in half circles was so that the interior columns could have their bases on the cellar floor level 35 ft. under water and be put in place before the cellar itself was dug, and then the cofferdams above the floor be removed. In fact, the entire Cedar St. end of the building and a good deal of the Liberty St. building will be erected before the cellar floor is put in place. At the present writing, four floors of the Cedar St. building, which are carried by 16 sets of columns, have been erected, and 9 ft. of the cellar at that end of the building have been dug. In a few days the second floor below the street level will be put in. This floor will be a solid concrete floor, built right up to the retaining-wall caisson, and will brace these walls against the tendency to overturn, caused by a 35-ft. head of water on the outside of the cellar. It is the intention to use a large portion of the circular cofferdams for smoke flues, making a double shell.

Counting the underpinning caissons, there are 81 caissons in all in these foundations, of which only three are not yet completed, and so far no man has been seriously hurt. Of course, there were a few cases of bends when the pressure got up around 30 lbs., and one man was paralyzed from the waist down, but two or three days in the hospital entirely cured him, while the men with the bends simply worked them off.

STOCK RAMMING.

The retaining-wall caissons having been sunk as close together as possible, the distance between the ends of the caissons varying from 6 to 15 ins., it was necessary to make a water-tight joint, so that the cellar could be dug 35 ft. below the surface of the water without drawing any material from behind the caisson, which would undoubtedly result in the destruction of the adjoining buildings. The only feasible scheme seemed to be stock-ramming, as adopted on the Commercial Cable Building, Broad and New streets, in 1896, in which case, however, the cellar was only dug 16 ft. below the surface of water. The first operation was to jet and drive with a pile driver a 3-in wrough-iron pipe down to the rock in the middle of the space between the ends of the caissons and cofferdam, which in the first case tried was 54 ft. below the top of the cofferdam. In the meantime good red clay from Jersey had been softened with water and thoroughly worked into a solid mass with mauls in a box. A scoop made by the blacksmith, by taking an old shovel and cutting and bending it in such a shape that when shoved down by the foot into the box of clay it would take out a pellet or core of clay in the shape of a cylinder, 2¼ ins. diameter and about 12 ins. long. These were piled up ready for use while the pipe was being driven, when about seven or eight were dipped in a pail of water and then dropped down the pipe, after which a steel rod 2½ ins. in diameter and 55 ft. long was dropped in the pipe, forcing the clay out at the bottom. The rod was then pulled up and more clay put in. When the weight of the rod was not sufficient to drive out the clay, half a dozen good hard blows were given by a 3,000-lb. hammer of a pile driver. When it was judged that enough had been driven at that elevation, the pipe was drawn up a foot and the operation continued, care being taken to scrape the clay off of the rod every time it came up, and to jet enough to draw the material about a foot or so on each side of the pipe, so that the clay would pack tight for a space of about 2 ft. or so, instead of spreading out sideways in layers and leaving layers of sand between. This pipe proved entirely inadequate, as it kept breaking, bending and giving no end of trouble, so new pipe 4 ins. nominal diameter was obtained at once, of which the outside diameter was 4½ ins. and inside 3.13 ins., the weight per foot being 27.48 lbs., and new piston rods, 2¾ ins. diameter, 15 ft., 30 ft., 55 ft. and 70 ft. long were ordered, and two pile drivers started as soon as the caissons were ready. The old 2½-in. rods were also used successfully in the larger pipe.

As soon as about 6 ft. of the pipe had been drawn up, the top section of the pipe was taken off and so on, until there was only about 15 or 20 ft. of pipe in the ground when the clay began to come to the surface, showing that there was no use of driving more.

The only way of telling how hard to drive was to watch carefully and use one's judgment, and it was found that great care had to be exercised so as not to drive too hard, because it was almost impossible to drive it hard enough and yet not move the caissons. These caissons and cofferdams formed a solid mass of concrete, firmly joined to bedrock, 8 ft. wide, 18 ft. long and 54 to 84 ft. high. Whether the clay shoved the entire caisson in the direction of its length, 18 ft., thus shearing a plane of concrete 8 × 18 ft., or whether it simply caused the caisson to bend vertically is not known. Sometimes the indications apparently pointed to the shearing—for instance, when the ramming was at the bottom, the tops of the two caissons seemed to come closer together, and as the ramming continued nearer the top, they parted again; and sometimes to bending, as when the tops never came closer together, but kept on spreading, sometimes getting about 1½ ins. farther apart than at the start.

It might be recalled here that at the new Croton Dam a single pipe which was used in the endeavor to stop a leak cracked and lifted 500 cu. yds. of solid masonry.

This did not surprise a certain Scot, who said that he had learnt it as a boy, when his mother in Scotland bought a barrel of butter and ordered him to put it in small jars. In endeavoring to get as much in each jar as possible, he rammed so persistently on the butter in the neck of the jars that he found he had broken the bottoms of many of them. A week before seeing the stock ramming on the Mutual Life Building, he had made some practical use of his early experience when "one of his bairns stepped on his cornet and bashed (stove in) it," which he remedied by filling the cornet with butter and pounding the butter

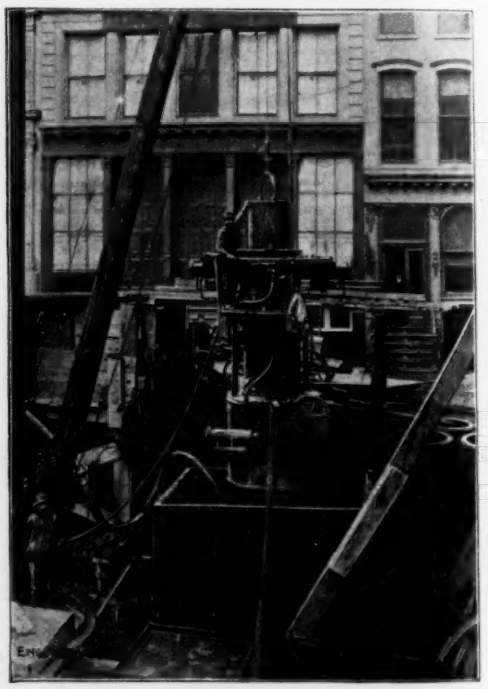

Fig. 13—View Showing Interior Foundation Caisson and Air Lock, New Mutual Life Building.

until the cornet was bulged out again; then all that remained to be done was to melt the butter, when his cornet was as good as new. Being a Scotchman, he saved the butter.

In spite of the utmost watchfulness and care there seemed to be an enormous variation in the capacity of the different joints, some taking 5½ cu. yds. and some as much as 16 cu. yds. About 225 cu. yds. were used altogether, and it took about 15 weeks for two drivers to fill 30 joints, varying from 54 to 84 ft. deep.

The oak skates between the caissons, which were about 5 ft. apart, undoubtedly saved a vast amount of clay by preventing it escaping from

the joints horizontally, as it did in the Commercial Cable Building, where there were no skates, and the clay was afterwards found 15 to 20 ft. away from the caissons in the lot. Of course below the top of the hardpan there was no opportunity to escape, and this may be the reason why it was so hard to avoid moving the caissons, although the orders were to drive easy until the pipe had been drawn above hardpan and then drive harder. At this time about a dozen joints have been uncovered to a depth of 8 ft. below the water surface without a sign of a leak, and one joint for a depth of 19 ft. with similar satisfactory results.

The present intention is to clean the joints back to the clay, and brick as far back as can be reached, and if brick cannot be placed in the rear of the hole, to fill the space with concrete. In bricking up, the brick work will first be stopped 12 ins. back from the face, when a single brick will be set in hot asphalt all the way up, then the remaining 8 ins. will be filled with good brick work. Portland cement, of course, will be used throughout.

CONCRETE FLOOR.

The present intention is to excavate all the material above hardpan for the cellar, and in a few places to take out a few feet of hardpan and then level up with 1 cement, 2 sand, 4 trap rock concrete, until there is about 2 ft. all over; then to lay a single course of brick in hot asphalt over the entire floor, and on top of this place 2 ft. more of good concrete.

While this floor will be at least 35 ft. below the surrounding water level, the hardpan is so dense that it is not thought that the water can ever act against the floor with its full head on the entire surface, and therefore it will not be necessary to brace or anchor the floor down with beams, etc.

The Commercial Cable Building was a much worse case, for there, although the floor was only 16 ft. under water, it rested on quicksand. There the weight of the concrete floor was 600 lbs. per sq. ft., while the pressure due to the head of water would amount to nearly 1,200 lbs. per sq. ft. Of course in time this head might cover the entire surface, but now after four years the concrete would have a good deal more than its mere weight to resist the strain.

QUANTITIES.

Some idea of the amount of work in the foundations may be obtained from the quantities of material used, for instance, 2,600 tons of steel will be left in the foundation, as well as about 20,000 barrels of cement, 10,000 cu. yds. of stone and 5,000 cu. yds. of sand. Approximately 45,000 cu. yds. of material will have been taken out and carted away.

The architects of the building are Clinton & Russell, of New York city, whose engineer is J. Hollis Wells, M. Am. Soc. C. E. Mr. Alfred Noble, M. Am. Soc. C. E., of Chicago, was called in as consulting engineer. Arthur McMullen & Co., Park Row Building, New York city, are the contractors for the foundations, and the writer is the engineer for the contractors.

A SYSTEM OF STEEL FRAMING FOR FREIGHT CARS.*

By G. W. Scott.†

Along with the industrial growth of the country at large has gone the development of the manufacture of steel and of the machinery by which that material may be rolled into sections convenient for general use. And so wide are the lines on which this development has taken place, and so ably is the process of manufacturing conducted, that steel may now be procured in sections well-nigh ideal for constructional purposes, and at a cost sufficiently low to constitute a strong commercial advantage in its favor. The conditions are all distinctly favorable to the introduction of steel as the ruling material element in car construction. Even now there are thousands of steel cars in active service, and the car building atmosphere seems laden with the thoughts of designs of others yet to come.

There may be some question as to what constitute the fundamental requirements in car design, but the following notes are submitted as being worthy of consideration in this respect:

(1) A car designed primarily with regard to the nature of car service in general.

(2) The use of materials which may be obtained as nearly as possible in their finished forms, and throughout the country at large, and preferably independently of any one manufacturer.

(3) The application of such materials in the simplest and most direct manner. This to promote economical construction and to admit of repairs and replacements being made with the least difficulty and expense.

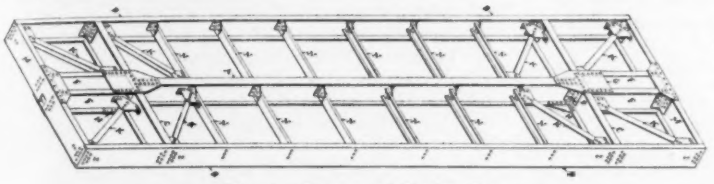

Fig. 1.—Design of Under Frame.

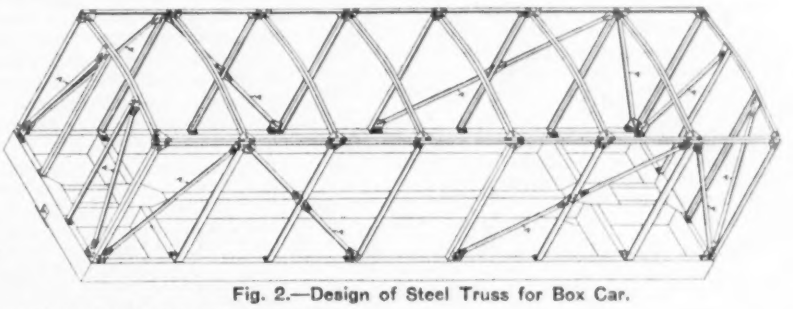

Fig. 2.—Design of Steel Truss for Box Car.

PROPOSED STEEL FRAMING FOR RAILWAY FREIGHT CARS.
Designed by G. W. Scott, Pullman, Ill.

(4) A system of under-framing competent to carry the whole of the dead and applied loads without assistance from any associated upper structure, and no less competent to hold up, structurally unimpaired, under the general conditions of car service.

(5) A system of under-framing in which the greatest possible proportion of the vertically applied loads shall be transmitted in the most direct manner to the center plate without producing a bending moment in the body bolster.

(6) A system of under-framing consisting of members having equal upper and lower flanges, between which the horizontal forces from and through the drawbars may be transmitted.

(7) A system of under-framing having a central rigid connection for the purpose of transmitting direct from drawbar to drawbar the shocks due to impact, in addition to the ordinary stresses consequent on the movement of the car or train.

There are, of course, many other requirements in detail; but it was with such general propositions as these in mind that the under-framing shown in Fig. 1 was designed. In its leading features the under-framing consists of a single center sill A with its ends abutting against the bolsters C, the connection with the latter being over the central portion of the center plate. The bolsters C are continuous throughout their length and have their ends framed with the side sills B, the latter extending the full length of the framing. Draft beams F bear directly against the bolsters C at the one end, and against the end sills M at the other; and the end sills M are connected, as shown, to the side sills B.

The system of under-framing so far described is uniform in depth, and thus renders easy the application of the upper and lower covering plates G and H at the connection of the bolster C with the center sill A and draft beams F. Other covering plates are employed at the connection of the draft beams F with the end sills M. The diagonal braces K are intended to add to the stiffness of the framing, and to transmit corner shocks to the rigid connection at the center of the bolster and to the center sill beyond.

In the design shown, the intention is to use a wooden floor; hence the floor beams N to carry suitable floor joists to which the floor may be fastened. These floor beams are also serviceable as lateral stiffeners.

The center sill and bolsters are standard I-beams, and that the side sills, draft beams and end sills are standard channels. The materials, then, are such as may be readily procured, and their sectional form renders unnecessary any special work being done upon them save that associated with their application. It may further be noticed that the several connections are reasonably simple in character.

One of the advantages of this system of under-framing is in the fact that by the use of standard commercial shapes it is possible to calculate within close limits just what sectional elements are required for a car of any reasonable length and capacity, and with any desired fiber strain or limiting factor of safety, relative to any assumed form of loading.

Requirement No. 5 is complied with in the most positive manner; for if it is granted that the center sill carries, say, one-half of the total load supported on the area between the bolsters, it is plain that this large proportion of the entire car load is transmitted practically direct to the center plate and, therefore, without producing any bending moment in the body bolsters.

The symmetrical character of the commercial I-beam and channel sections, and their equally symmetrical disposition as indicated in Fig. 1, are in accord with requirement No. 6; and with regard to requirement No. 7, it may be said that while a single center sill may be unusual, reflection will show that it is a correct solution of the problem with regard to the direct transmission of stresses from drawbar to drawbar. It has also been shown that a single center sill has an advantage in transmitting direct to the center plate its share of the vertically applied load; and it will be further recognized that the use of one center sill instead of the customary two is a desirable feature from an economical and constructional aspect.

The system of under-framing described is applicable to a flat, gondola, drop bottom, hopper bottom or box car; the framing being substantially the same in all cases, only the floor and upper structure differing. It will also be clear that the floor and upper framing may be constructed of wood or steel as required. The system of under-framing can also be used in combination with the system of upper-framing for a box car as shown in Fig. 2. In this case it is assumed that the under-framing is sufficiently strong to carry its dead and applied loads without any assistance from the upper-framing, and, therefore, the strength of the upper-framing need not be considered beyond its ability to withstand wind, inertia and other shocks incidental to the ordinary operation of cars in service. This arrangement is advantageous, for each portion of the under and upper framing can then be considered more definitely with regard to its purpose, thus admitting of a reasonably correct design and an economical use of material.

The use of angle of T-sections carlins, as shown in the arrangement of the upper-framing (Fig 2), results in a decided gain in head room, and to an extent equal to the difference between the depth of the steel section employed and that of the wooden car line which otherwise might be used. It may also be noticed that this system of upper-framing admits of the application of either wood or steel as the material for the car siding, lining or roofing.

There are few principal members, and these are arranged in what is believed to be the best manner consistent with their purpose. These members are standard commercial sections, and therefore such as may be readily procured throughout a large portion of the area traversed by railroads. Furthermore, the design of the under-framing is entirely free from complexity, and the connections of the principal as well as those of the subordinate members are in keeping with the simple character of the construction, all of which constitute, as a whole, conditions the significance and importance of which can best be appreciated by those concerned with the cost and operation of car repairing.

As an argument against the use of rolled commercial sections for car construction, the statement is occasionally made that a car constructed of commercial sections is necessarily heavier than one of similar capacity built of pressed steel shapes. It is noticeable, however, that the only figures accompanying such statements are those referring to the dead weight of the car and its assumed and stenciled load capacity. For the purpose of a proper and direct comparison, the dead load should be expressed in terms of the ultimate carrying capacity of the car; or if the stenciled load capacity is desired as a base for consideration, it would be well to know what ratio the stenciled capacity bears to the ultimate load capacity of the car. In other words, for a given form of loading—say, uniformly distributed—what is the factor of safety considered with reference to a static load of so many thousand pounds? This form of treatment would admit of a direct comparison being made, but in the absence of this, or similar direct information, a mere reference to a stenciled capacity is scarcely sufficient for purposes of comparison.

It has already been stated that one of the advantages in connection with the system of under-framing herein described, is in the fact that by the use of standard commercial shapes it is possible to calculate within close limits just what sectional elements are required for a car of any reasonable length and capacity. It follows, therefore, that if the dimensions of the sections entering into such a system of under-framing as the one described are known, the ultimate carrying capacity of the structure can readily be determined.

The value of this feature is self-evident in that it enables those interested to ascertain the strength of the car, and this with a degree of precision rather difficult of attainment in the case of pressed steel shapes, whose original strength may be more or less reduced by the distorting and straining action practically inseparable from the process of manufacture.

*Abstract of a paper presented at the March meeting of the Western Railway Club.

†Pullman Car Co., Pullman, Ill.

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Some of the figures in Governor Odell's message on the New York canals, upon which we commented last week, were incorrectly printed in the press abstract from which the part we quoted was taken. A correct print of the message is now before us, and we reproduce the part of the message in which the error occurred as follows:

Under the present Erie Canal the cost per ton mile, according to the Greene report, is 1.75 mills, and under the Seymour plan, the act of 1895, if the canal were completed according to those plans, the cost would be 1.16 mills, while under the proposed barge canal it would be .88 mills. This, of course, represents only the carrying charges, and has nothing to do with the interest on the investment. In making a comparison with the railroad charges it should be added. Taking the most favorable basis and estimating that the tonnage would exceed 10,000,000 tons, there should be added, if the fourth plan should be adopted, the interest on the ultimate cost, which would be $110,000,000. This at 3% would be $3,300,000. Adding this to the mere cost of transportation of .88 mills per ton mile, the result would be 1.54 mills. Completing the canal under the plan of 1895, the new capital would be $25,143,241, which at 3% interest, and estimating the tonnage at 10,000,000, would be 1.31 mills per ton mile. The only difference in the cost per ton mile between the $25,000,000 plan and the barge canal would be .23 mills per ton mile in favor of the $25,000,000 project.

Reference to the Greene report ["Committee on Canals of New York State, 1900; p. 28] shows that the estimate of the Greene committee for the cost of freight movement in a 1,000-ton barge canal was 0.52 mill per ton mile. The estimate of 0.88 mill per ton mile, which the governor quotes, is that committee's estimate of the cost of carriage in a canal of 8 ft. depth, suitable for 450-ton barges.

When the proper correction is made it will be seen that the supposed advantage of 0.23 mills per ton mile in favor of the $25,000,000 improvement as compared with the 1,000-ton barge canal wholly disappears.

It appears to have wholly escaped public notice that the Greene committee presented two alternative propositions for barge canals. Besides the scheme for a 1,000-ton barge canal which it so urgently recommended, it also proposed a scheme for a canal suitable for smaller barges, 125 ft. in length, 17½ ft. wide and 8 ft. draft, to carry a load of 450 tons. It estimated the cost of a canal to accommodate such boats at only $21,000,000, or $4,000,000 less than Governor Odell is now proposing to spend to complete the discredited project of 1895.

As stated last week, we see no possibility that the project to complete the 1895 project at a cost of $25,000,000 can be approved by either the legislature or the people; but if any such sum is to be spent on the New York canals, then by all means this modified barge canal recommended by the expert commission a year ago as an alternative to the 1,000-ton barge canal would be vastly preferable to going on with the discredited "nine million dollar" plan of improvement.

We should not be understood as recommending such a canal; and the Greene committee did not. They explicitly said:

We believe it to be unwise to spend large sums of money in a mere betterment of the existing canal. * * * We do not believe that the adoption of the smaller plan [the alternative plan above referred to] will result in *permanent* benefit to the State of New York. * * * We became convinced that the completion of the project of 1895, as originally designed and producing a waterway to be used by boats of 320 tons, would give so slight an improvement over existing conditions as not to justify the expenditure of public money.

In view of these plain statements by an expert commission, and of the well known state of public opinion, Governor Odell's plan to spend $20,000,000 to $25,000,000 in completing the patching-up process begun in 1895 appears wholly inexplicable.

One reason why the governor rejects the 1,000-ton barge canal project is because he thinks that even when completed it could not compete with the Canadian 14-ft. waterway to the seaboard. "Under the most favorable conditions," says he, "the distance from the port of New York to Liverpool would still be several hundred miles further than from Montreal."

The actual distance from Montreal to Liverpool is 3,220 miles, and the distance from New York to Liverpool is 3,540 miles, a difference of only 320 miles in favor of Montreal. Against this supposed advantage is to be set the danger and delay of navigating the St. Lawrence River and Bay in the thick fogs which hang over these waters during a large part of the year. These dangers are reflected in the increased rates of marine insurance which are demanded for vessels and cargo entering or leaving St. Lawrence ports. It is quite probable that this feature more than offsets the small advantage in distance which Montreal possess. The danger of collisions in fog will rapidly increase with any increase in the number of vessels using the St. Lawrence route. It is also to be remembered that the port of Montreal is closed by ice during a large part of the year.

Under these circumstances it is absurd to speak as if New York were necessarily at a disadvantage over Montreal as a grain exporting port. The high cost of handling and transferring cargo in the port of New York is probably a far greater handicap to it in competing with Montreal than is its greater distance from English seaports.

A determined effort has been made by certain newspapers to show that the loss to American manufacturers through the recent increase in Russian duties on American goods was not a very great amount any way. Even the Bureau of Statistics at Washington appears to have been enlisted in this work, and it issued a bulletin some time ago purporting to show that the damage to American exporters by the Russian tariff retaliation had been much overestimated.

Now statistics are fine things; but if unintelligently interpreted they will very often lead one away from the truth instead of toward it. The figures of the Bureau of Statistics show only the country to which goods are primarily destined as they leave the United States. On this basis, the Bureau claimed that the total exports of the United States to Russia were less than $10,000,000 per annum. It is said to be a fact, however, that a large proportion of American goods destined to Russia are shipped first to Hamburg or some other North Sea port; and the Russian statistics of imports from the United States are said to show a total of over $25,000,000. In connection with the increase of duties on American goods, Russia has also made an order requiring the country of origin to be shown on imported goods, so that the increased duties will be levied on American machinery even though it is shipped through Germany.

Altogether the American manufacturers were hit by the new Russian duties appear to have been better informed about their own business than were the partisan newspaper editors and the Bureau of Statistics, who endeavored to make out that the whole affair was of small importance.

Since the above was in type, we have received a letter from Mr. Wm. L. Saunders, M. Am. Soc. C. E., President of the Ingersoll-Sergeant Drill Co., in which a detailed explanation is made of the methods by which the Government statistics of exports are made up, and of the large percentage of inaccuracy which they contain as respects the country of final destination of the exported goods. We quote as follows:

The export statistics are built up on the statements (clearances) given by the export merchants, and these statements, being each one sworn to, are fairly reliable so far as they go. But the error comes in in connection with the printed wording of the clearance blanks. When the heading reads: "To be landed at," the merchant fills in the name of the port where the goods are to be landed. There is where the mistake comes in. Switzerland, for example, has no seaport, so if goods are shipped for Switzerland the exporter will clear them as going to Antwerp and when the custom house clerks come to compile their returns that shipment will be classed under the heading of "Exports to Belgium."

Mr. Saunders further explains, however, that Switzerland and other countries having no seaports are not entirely ignored in the statistics, because the custom house clerks will sometimes substitute the country of final destination for the country of landing if the bill of lading or the "marks" on the clearance sheet give them a clue. In general, however, such countries as have direct steamer connection with the United States are put down as receiving much more of our goods than they really do, and appear as much larger customers of the United States than the facts warrant. Thus, Great Britain appears to take an enormous proportion of our total exports to Europe, but the figure given for the last year of $527,000,000, would dwindle down considerably if all shipments were deducted that merely touch Great Britain, and were really intended for other countries. On the same principle, the figure of $89,000,000, given as our exports to Holland, would lose by far the greater part if the shipments which are merely passing through that country and are really intended for Germany were deducted.

Applying these facts to the Russian tariff war, Mr. Saunders says:

The government figures state our exports to European Russia as $7,420,000 for the year 1899-1900. In reality they were much larger. Numerous shipments go to that country by way of England, Denmark or Germany that never appear in our statistics under the heading of "Exports to Russia." A large portion of the goods intended for Russia go to Hamburg not on a "through" but on a port bill of lading and are transshipped from Hamburg either by rail or by steamer.

Secretary Gage has issued a statement showing that out of our total exports to European and Asiatic Russia only about $3,000,000 were effected by the retaliation duty recently imposed by Russia, thereby intending to show that the tariff war was of small importance. These figures are nowhere near the true figures representing American business in Russia. This large market has few seaports and during the winter months only one (Riga) is an open port. The result is that goods are consigned to European ports of other nations and re-shipped into Russia.

It is queer how certain newspapers persistently deceive the public with regard to this Russian tariff matter. The attempt to show that the loss to American trade is trivial, we have sufficiently reviewed above; but various other misstatements have also been circulated. It was said, for example, that Russia's threat was only a "bluff," because two weeks' delay was given before the increase of duties went into effect. Events have proved that M. de Witte, the Russian Minister of Finance, has done exactly as he said he would do, and has not swerved a hair's breadth.

It has been said that M. de Witte's real motive was not retaliation for the United States' countervailing duties on Russian sugar, but a de-

sire to aid Russian industries by raising the tariff on imports. The childish absurdity of this conjecture is seen in the fact that the increase applies only to the United States. English and German and French machinery still go into Russia at the old rates. Were this not the case, the American manufacturer could still sell goods in competition with those other countries, and the increased tariff rate would fall on the Russian buyer. As things are, however, the American manufacturer, in the fields covered by the retaliatory tariff, is squarely knocked out; and all the excuses of partisan newspapers or Government bureaus cannot alter the matter.

ANNUAL REPORTS OF THE STATE SEWERAGE COMMISSIONS OF CONNECTICUT AND NEW JERSEY.

While Massachusetts, New York and Ohio have vested more or less sanitary control of the waters of the respective states in their state boards of health, Connecticut and New Jersey have created sewerage commissions to conserve their inland waters. In Massachusetts and Ohio, the state boards of health pass upon plans for new water supply, as well as upon those relating to sewage disposal. In New York the state board of health, and in New Jersey the state sewerage commission, has control over plans for sewage disposal, only. The New York board of health, however, has authority to formulate rules for the protection of public water supplies.

The Connecticut sewerage commission is an advisory body, created to "investigate methods of sewage purification and construction of sewerage systems and sewage disposal works." It has power to summon witnesses, is required to make an annual report to the governor, but, under the act of 1899, the commission expires on June 1, 1901.

The New Jersey commission not only passes on all plans for new sewerage works, but has full authority to order any sewage pollution stopped within such a period as it sees fit, not exceeding five years. Both the Connecticut and New Jersey commissions have just published their annual reports for 1900, which include accounts of visits to European sewage purification works, three members of the Connecticut and one member of the New Jersey commission having gone abroad.

THE WORK OF THE CONNECTICUT SEWERAGE COMMISSION.

The Connecticut commission consists of five members, appointed by the governor. It organized by choosing Prof. Edw. H. Jenkins, of New Haven, as chairman, and Mr. R. A. Cairns, M. Am. Soc. C. E., of Waterbury, as secretary. The commission was given an appropriation of $500 per member per year for expenses and each member has a salary of the same amount.

During the year and a half covered by the report the commission has received requests for advice from New Britain, West Hartford and Waterbury, relating to proposed sewage purification works. It advised New Britain to experiment with intermittent filtration, and tacitly approved the adoption of that method, after securing some mechanical analyses of soil from the proposed filtration area. It advised West Hartford to adopt septic tanks and bacterial filter beds, both covered, unless it could find a better area for intermittent filtration than the one under consideration, but believed the proposed connection with the Hartford sewerage system would be a happy solution of the problem confronting the town. For Waterbury, intermittent filtration was advised, in accordance with a plan recommended in 1896 by Mr. Rudolph Hering, M. Am. Soc. C. E.

Both New Britain and Waterbury are being forced into action by riparian owners and the courts. Since the first successful damage suit, in 1892, New Britain has paid $40,000 to $50,000 in judgments, or in settlements out of court, on account of water pollution, besides which there are outstanding claims to a total of about $100,000. It is now confronted by an application on the part of the city of Hartford, Conn., for a perpetual injunction against the further pollution of Park River, which flows through Hartford. Waterbury was in the courts from 1895 to 1898. In the latter year the plaintiffs, Platt Bros. et al., secured an injunction against the city, prohibiting the discharge of sewage into the Naugatuck River during June to October, inclusive, of each year, the injunction to take effect on Dec. 1, 1902. In 1899 this decision was affirmed by the Supreme Court of Errors.

During their tour abroad in the spring of 1900 the three Connecticut commissioners visited sewage purification works in 21 English cities and towns. Five of these plants are described in the report; those at Manchester, London, Sutton, Accrington and Exeter. At each of these places the sewage is or has been treated in septic tanks or filter beds, the Manchester and London work being experimental. The experience at all these places except Accrington has been published widely in this country. At Accrington a septic tank and bacterial filters have been substituted for chemical precipitation, the septic effluent being sprinkled upon coke beds 9 ft. deep, under the Whittaker patents. This portion of the Connecticut report is accompanied by some fine half-tone views.

After describing the five plants named the conclusions based on the inspection of English practice and experiments are given. This summary we have condensed as follows:

(1) Chemical precipitation has proven unsatisfactory for the treatment of domestic sewage in England. It may be desirable for the joint use of certain manufactories.

(2) Some form of bacterial purification is the only method of general promise to-day.

(3) Intermittent filtration has been shown to be a highly satisfactory method of treating sewage, particularly in Massachusetts and Connecticut, and largely through the experimental work of the Massachusetts State Board of Health.

(4) Intermittent filtration has well known limitations, particularly where the soil is heavy or where land is expensive, as in England.

(5 and 6) Bacterial filters will handle six to eight times as much sewage on a given area as intermittent sand filters, and while "the effluent is not nearly as pure" it is "pure enough to meet the present requirements of sanitary authorities." The mild climate of England does not appear to affect seriously the working of these beds.

(7) Bacterial beds also have their limitations. They are of such coarse material that sludge passes down into them. While much of the sludge is subsequently liquefied it seems probable that a more extended experience will show that bacteria beds will become so badly clogged in time as to require complete renewal, if they receive crude sewage.

(8) English experience shows that the most efficient means of cleaning the sewage of sludge before it goes to the filters is the septic tank. In some cases bacterial filters alone may prove to be sufficient. Considering the legal restrictions imposed, the soil and geographical conditions, the English work is still in the experimental stage, but "the septic tank is no longer an experiment;" and it appears that the bacterial beds will be able to receive sludge-free sewage without renewal.

(9) Manufacturing wastes may require separate and special treatment.

In conclusion, the Connecticut commission states:

(1) That each community is under obligations to the public to dispose of its sewage without nuisance, working out its own problem "for itself, with such state supervision and control as is necessary in the public interest."

(2) In the future no community, individual or private corporation, now without sewerage, should be allowed to discharge "sewage or polluted water into any stream."

(3) The legislature should grant no authority for new sewerage work until plans for sewage purification have been presented to and approved by "some competent state authority."

(4) The sanitary operation of present or future sewage disposal works should be under state control.

The commission recommends that its work be continued and that provision "be made for the construction of an experimental septic tank and contact filter bed to test the efficacy of this system of treating sewage in our climate."

THE WORK OF THE NEW JERSEY SEWERAGE COMMISSION.

The commission was organized in May, 1899, but a revision or re-enactment of the statute under which it was appointed led to a cessation of formal work during April, 1900. The commission consists of five members. Mr. Wm. T. Hunt, of Newark, N. J., is chairman. Mr. Boyd McClean, who is not a member of the commission, is secretary. Each member of the commission receives a salary of $1,500 a year. The commission has had, thus far, a yearly appropriation of $2,500 for expenses, but during the state fiscal year ending Oct. 31, 1900, the commission expended only $1,087, the balance reverting to the treasury. It states that the appropriation was more than ample "for current expenses, but unfortunately was not sufficient for organizing the original investigation which is necessary." Accordingly, it asks for a larger general appropriation, to enable it to make "the inquiries, tests and surveys which localities have a right to ask of a state body which is strict in its requirements." It feels that it is unfair for the commission to demand costly changes in local sewerage systems without at the same time supplying the communities affected "with facts and figures to guide them in a proper decision."

The most important problem before the commission has been the abatement of the pollution of the Passaic River valley, which it has ordered completed by June 1, 1904. Up to the close of 1900 practically nothing had been done to comply with the order. The commission suggests the need of further legislation to prevent undue delay in carrying out its orders.

Aside from the Passaic River pollution, to which a dozen or more cities and towns contribute, including Newark, Paterson and Passaic, the commission has notified the town of Red Bank to cease polluting the Navesink River before Oct. 1, 1901. It also advised the city of Plainfield that prompt action was needed to remedy the unsatisfactory condition of its intermittent filtration area, some parts of which had been flooded for a year or so.

In addition to the instructions to cease pollution, noted above, the commission approved quite a number of sewage disposal plans during the year, including a septic tank and filter beds for the borough of Collingswood; the same method for the borough of Merchantville and also for the new State Reformatory at Rahway; and intermittent filtration for the borough of Vineland, N. J. It may be added that since the report was written the commission has approved plans for septic tanks and bacterial filter beds for Plainfield, to take the place of the intermittent filtration area.

The chairman of the commission contributes an interesting "Report on Foreign Methods of Sewage Disposal," based chiefly on what he saw in Great Britain and France in May and June, 1900. Our readers have already had the benefit of some of the information and ideas obtained by Mr. Hunt on his trip; first, in an article published in our issue of Sept. 13, 1900, summing up the conclusions drawn from the experimental works at Leeds, and, second, in a letter published in our issue of Feb. 7, 1901, under the title "The Bacterial Treatment of London Crude Sewage."

Mr. Hunt reviews the recent experiments with bacterial treatment at London, Leeds and Manchester, briefly describes the chemical precipitation plant at which a part of the sewage of Glasgow is treated, and outlines the conditions at Paris, including the removal of sewage from the Seine, and the sewage farms some distance from the city.

Mr. Hunt found no "methods of sewage disposal or treatment not known or well understood in this country," but he did find a more extensive experience abroad than at home, a greater liberality both in time and money allowances for preliminary investigations, and a more thorough appreciation of the fact that "the treatment of sewage and the purification of rivers is an expensive work." The cost of labor, he believes, is not much less abroad than in the United States. The consumption of water and use of the sewers "is generally far below that prevailing in this country." Combined systems of sewerage are the rule. The

degree of purity required for sewage effluents is being increased. In conclusion Mr. Hunt says:

The tendency in England where the experiments have been chiefly conducted, is undoubtedly in favor of sewage disposal upon the so-called septic tank and double-contact plan, where broad-irrigation by sewage farms, is impracticable. The Leeds and London experiments, the extended tests at Manchester, and the demonstrations by Mr. Cameron, the inventor of part of the process at Exeter, have indicated, though not proven, that purification of sewage sufficient to avoid inury to a water-course not used for domestic supply may be obtained by straining, septic or annerobic treatment in tanks, followed by passing twice through coke or cinder beds. Add to this a sand filter, or a partial application of land treatment, and a very complete purification is obtained; and it is believed by many that harmful bacteria are removed entirely. If Manchester develops this system thoroughly, as now seems probable, and the results, after three or four years, meet expectation, a great stride will have been made. For small plants the success of the system may be said to have been satisfactorily established.

In the application of systems of sewage treatment observed abroad to New Jersey conditions, it would seem to be shown that the state commission may with safety approve the more thorough bacterial systems of treatment, retaining control should the effluent prove unsatisfactory, and that brood-irrigation remains the certain method where soil is favorable and space ample. The desirability of joint action by two or more cities, so as to have the works under a single control for an entire drainage district, is apparent by greater success attending the methods of the larger cities of Europe. The construction of trunk sewers and interceptors is becoming more familiar, and, therefore, a simpler task. The discharge of crude sewage into any stream would seem inadvisable, but treatment may vary from simple straining and mechanical precipitation up to complete bacterial purification according to the waters into which the effluent is to be discharged.

COMMENTS ON THE TWO REPORTS.

It is gratifying to note the good work already done by these two commissions. Each has far more than justified its existence, and each might well be entrusted with the larger appropriations which will be absolutely necessary to enable it to carry on the investigations which would be required if a large and complicated scheme of sewage disposal came before it for approval. It is to be hoped that the Connecticut commission will be continued, and that it will be granted the same prohibitory control over water pollution and like power of approval or disapproval of contemplated sewage disposal works as is vested in the New Jersey commission.

The great weakness of such commissions, and of State boards of health to whom such general powers have been granted, is that they are seldom provided with sufficient authority or machinery to enforce their orders. The Connecticut commission, as stated at the outset, is merely an advisory body, but the New Jersey commission can issue orders for the abatement of the pollution of any of the inland waters of the State. The difficulty lies in a prompt enforcement of such orders, particularly where a number of communities are involved. The Passaic valley is an illustration of this. The New Jersey commission issued orders last summer to the municipalities involved, for the cessation of all pollution of the lower Passaic by June 1, 1904. Although every day of the four years given was needed for the study of the problem and the construction of works, no practical steps have yet been taken for the organization of the sewerage district generally conceded to be necessary before studies, even, can be started. The commission recognized its weakness in this particular, and, we understand, was responsible for the introduction of a bill in the legislature, providing that where its anti-pollution notices were not obeyed when its time limit had half expired, the commission might proceed to make the necessary improvements. Some of the people in the Passaic valley sought to remedy their particular trouble by securing the formation of a sewerage district by the legislature and the appointment of a commission by the governor, with authority to raise money and build sewage disposal works. Neither bill became a law, the district measure failing through the oversight of a technical point, which could not be remedied at the last moment because of the coalition between the real opponents of the bill and a faction bound on revenge for the legislation which it had unsuccessfully opposed. Notwithstanding the failure of these two measures, much might be done under existing legislation if the communities which have already expressed a willingness to work together would inaugurate some of the necessary preliminaries, or if the State Sewerage Commission had funds to enter upon some of the investigations needed in the interests of the whole State. This last idea suggests the inquiry: Why did not the commission utilize its full appropriation, small as it was, instead of letting $1,500 return to the State Treasury at the end of the fiscal year? With no more than $1,500 it might have studied the results being obtained at some of the sewage purification works in the State; or doubtless it could have secured the co-operation of the communities most directly interested, and studied the septic effects in the long conduit, and the tidal chamber of the Orange-Montclair outlet sewer. Such a study was suggested last summer at the conference between the commission and representatives of the communities which are polluting the Passaic River.

Finally, it is interesting to note that both the Connecticut and the New Jersey commissions still look with favor upon the old methods of land treatment, under suitable conditions, instead of being completely carried away with the claims so vigorously urged in some quarters for septic tanks and double contact filters. In their attitude on this subject they seem to stand between the very conservative position held for several years by the Massachusetts State Board of Health and the recent attitude of the Ohio State Board of Health in disapproving, for the present, the proposed septic tanks at Columbus, O.

LETTERS TO THE EDITOR.

No Trouble With Ventilation of the Cascade Tunnel.

Sir: I notice in your issue of March 14th, an article which says that the operation of the Cascade Tunnel on the Great Northern Ry. is hampered by serious difficulties, due to defective ventilation. I will say that there is no truth whatever in the statement that we are experiencing difficulties in the operation of this tunnel from smoke or gases. We are more than pleased with the results which we have achieved, and are not planning to operate it by electric power; at least, not at present, and all such statements as those contained in the article in question are absolutely false. They were undoubtedly originated by some irresponsible daily newspaper correspondent, and I wish to deny them in every particular. Truly yours,

Jno. F. Stevens, Chief Engineer.

St. Paul, Minn., March 21, 1901.

Burning Powdered Fuel.

Sir: I have read the article describing Mr. Westlake's coal-dust firing device in your issue of March 14, but was somewhat surprised to find that among the many patented coal-dust burning devices only one other, that of Karl Wegener, was mentioned. There are at least four more patentees, who, with Wegener (or even prior to his invention), have more or less successfully operated fuel dust burning apparatus. Of course, they were all of the blast type, and consequently less efficient. The operation of our plants has been kept back by the lack of an efficient and economical grinding mill. We expect soon to have a coal-grinding mill and a dust-burning apparatus in operation. This will demonstrate how Mr. Schwartzkopff's idea, together with mine, will do away with the use of grate-bar firing, which is employed with Mr. Westlake's device.

A. C. Hesselmeyer,

Tech. Manager Schwartzkopff Coal Dust Firing Co.

203 Security Building, Chicago, Ill.

The Reports of Members of the Corps of Engineers on River and Harbor Projects.

Sir: In the editorial entitled "The Defeat of the River and Harbor Appropriation Bill," in your issue of March 14, 1901, you quote from Senator Carter's speech a kindly criticism upon the engineers of the army which hardly seems to be justified by the facts. Senator Carter says:

One word in closing about the engineers of the army. It rarely occurs that an engineer of the army reports adversely upon any project he is directed to survey.

A list of preliminary examinations and surveys from the beginning of the government to and including 1897 is published in "Document No. 482, House of Representatives, 55th Congress, 2d session." This list covers 1,192 examinations and surveys upon which definite recommendations were submitted by the engineers. Of these, 553 were reported favorably and 639 unfavorably. In other words, 46% of the reports were favorable and 54% were unfavorable.

Truly yours,

C. W. Raymond.

U. S. Engineer Office, 815 Witherspoon Building, Philadelphia, March 21, 1901.

More About the Glover Septic Tank and Filter Bed Claims at the County Farm, Brentwood, N. H.

Sir: Mr. Arthur W. Dudley, C. E., in your issue of Feb. 21, makes certain statements which, if correct, will lead to the recovery by the heirs of the late Amasa S. Glover of a large sum of money due to them from Rockingham Co., N. H. He is a valuable witness, not only because he knew of the conditions of the small brook which drained the county farm, before and after the erection of the Glover system of sewage disposal at Brentwood, and has a positive knowledge of the contract between Mr. Glover and the county, the original copies of which were one accidentally and the other designedly lost, but also because he is a leading engineer in the United States in publicly giving his approval to septic action and filtration for sewage disposal, according to his own statement.

Mr. Glover, I was informed by the manager of the [illegible] works at Exeter, N. H., bought a large quantity of coke of the latter and had it transported to Brentwood for use in the small filters. What became of that coke? Mr. Dudley asserts that the filter was completely solidified. Under the sand which formed the surface, unwashed and unscreened gravel, with a considerable admixture of loam and clay, had been used, and this had completely clogged the bed.

The shame of it! That coke was bought in Exeter and delivered at the works at Brentwood and Mr. Dudley found "loam and clay" in the filter. Somebody stole the coke. Mr. Dudley claims an alibi, and states that he was in Manchester during the season of 1895, but considers "Brentwood a poor locality" ("to establish Mr. Glover's fame or his company's rights."—Ed.).

Brentwood, one of the oldest towns in America, as a part of Exeter, was settled in 1638. It was incorporated as a town in 1742. Generations of honest New England yeomen have tilled its fields, defended their homesteads from Indian foes, and their country from foreign aggression, worshipped God and governed their little republic with wisdom and honor. Brentwood is a fine locality, beautifully situated and already famous. There is no resident of Brentwood so poor, so needy and so dishonest as to steal Mr. Glover's coke. The inmates of the county farm buildings, poor old wrecks of humanity, stranded by adverse wind and tide, gathered from near and remote towns of old Rockingham, had they anything to gain by the act, would have scorned to injure such a fine old gentleman as Amasa S. Glover by stealing his coke.

Mr. Glover "completed the work" late in the season (1895) and asked for its acceptance. The commissioners, however, "decided to wait a while to see how the thing operated," according to Mr. Dudley.

If the coke had been abstracted and used in the furnace of the pumping station of the poor farm, the only place to use it within miles, and had been replaced by unscreened gravel, mixed with clay and loam, and concealed by a coating of sand, it requires no expert knowledge to know that such a filter would quickly become solidified. Had the coke been used Mr. Dudley would have informed them that the thing would operate. They did not pay the $800 due to Mr. Glover, although they must have known that the building of field-stone, covering elaborate concrete tanks, designed by and built under the supervision of an architect, must have cost Mr. Glover many hundred dollars more than he was to receive as pay.

"They had, during construction," Mr. Dudley says, "been obliged to furnish a considerable amount of material and labor used" ("as Mr. Grover's capital proved to be very limited."—Ed.). Mr. Dudley's statement makes it clear that this material was gravel mixed with clay and loam, and the labor was employed in replacing the coke with such material. Raw material and pauper labor on the poor farm! And it is a fact that the commissioners of Rockingham Co. attempted to collect this bill for labor and material of the Glover estate.

Mr. Dudley makes certain statements at the close of his letter which are liable to injure me in my business and reputation, and which demand correction.

In 1898 I had a conference with the newly elected board of Rockingham Co commissioners in regard to correcting the faults in their sewerage system at Brentwood, which had been built years before, without any attention to line and grade. They informed me that they had employed a local engineer to do the work. In the fall of 1899 I had a conference with the commissioners in the presence of my attorney, Col. Francis S. Hesseltine, of Boston, and it was then and there agreed that the works at Brentwood were built and operated under the Glover patents; that our company could advertise them as such; that the commissioners could be referred to as to their successful operation; that the works might be visited in our interests; and that the superintendent of the farm might distribute to inquirers our literature on the subject.

The only fault I ever found with the commissioners was their intrusting not the sewerage system at Brentwood to Mr. Dudley, but the repairs on the patented sewage disposal works in which I was personally interested. They probably now regret having done so.

As the filter only worked a short time at Brentwood, the purification effected in the sewage from 1895 to 1898, to cause the town through its agent, Mr. Dudley, to withhold any complaint, must have been largely the result of septic action. Whether the filter Mr. Glover designed for the effluent from the tank would have produced 95% or 99% purification, Mr. Dudley cannot state, except from hearsay, because the coke was stolen and a clay and loam filter was substituted for it.

The works which the American Sewage Disposal Co. of Boston have advertised at Brentwood as operating under the Glover patents are as Mr. Dudley left them, with the

capacity of the septic tank—already too small—diminished by him about one-third, by placing the invert of the inlet sewer pipe some 18 ins. below the top of the septic tank; and with the efficiency of the filters, the area of which he doubled, diminished in about the same proportion as the tanks.

The question arises: If the full capacity of the septic tanks had been utilized and the present depth of 3 ft. of the septic sewage made 4½ ft., what purification would be effected by the original filter of coke half the size of the present one, but 50% deeper, compared with the present satisfactory purification?

I wish to thank you for the eminent fairness with which you have treated myself and associates and our claims.

Yours truly, John N. McClintock, A. M., C. E.,
Prest. American Sewage Disposal Co.

89 State St., Boston, Mass., Feb. 25, 1901.

(In accordance with our custom in such cases, we submitted a proof of Mr. McClintock's letter to Mr. Dudley. The reply of the latter is given below.—Ed.)

Sir: Mr. John N. McClintock, in his reply to my letter in your issue of Feb. 21, claims me as a "valuable witness" to establish the validity of the Glover claims against the Rockingham County authorities, on account of the sewage disposal works at the county farm at Brentwood, N. H. As my desire and intention has been to tell the truth about the matter, so far as I know it, and I have no interest whatever to do otherwise, it makes little difference to me whose interests are affected by my statements.

What I said about the brook conditions were under rather than overstated. In regard to my contract between Mr. Glover and the former board of commissioners of Rockingham county, and the conditions of that contract, I know only what was told me by the commissioners. Mr. McClintock's statement that a copy of this alleged contract was designedly lost, seems rather a broad one for a man to make, who could have known nothing of the matter. He assumes that the coke, of which he says that the manager of the gas works at Exeter, N. H., informed him that "Mr. Glover bought a large quantity," was stolen. Let us see about this. An examination of the books of the Exeter Gas Co. does not show that Mr. Glover ever bought a cent's worth of coke there. Neither can Captain Cooper, the superintendent, remember of any transactions with Mr. Glover. The books do show that in December, 1895, some 200 bushels, costing about $17, were sold to the county of Rockingham. This was transported to Brentwood by the county teams, and paid for by a check from the county treasurer. Where does the stealing come in? It must be, if any was used, and a small quantity was found mixed with loam, gravel and clay, that Mr. Glover, or some one in his interest, stole the county's coke. The facts are, as before stated, that Mr. Glover had no ready money to pay for any materials used, and the county authorities paid almost all bills for material, coke included. Their account actually exceeded the stipulated sum of $800 which Mr. Glover agreed to accept, when he fulfilled the conditions of his alleged contract, and which he never did fulfil. They also, under the supervision of Mr. Glover or his foreman, furnished all the labor employed. It was not all pauper labor, either. It is a fact that they attempted to collect this bill for labor and material from the Glover estate. What a state of affairs?

Although Mr. McClintock strains himself badly to make me say that "Brentwood is a poor locality," I must thank him for his characterization of my native town. It is famous in history. It furnished more soldiers for the Revolution in proportion to its population than any other town in the State. I take a pardonable pride in the fact that my own immediate ancestors were those who in 1638 made the first settlement within its borders, and built upon the spot where I now reside, the garrison house, which was the western outpost for the defence of the settlement of Exeter from Indian foes.

We have no desire to steal Mr. Glover's coke, or to rob him or his successors of any just right whatever. Mr. McClintock says that in 1898, and also in 1899, he had conferences with the Rockingham county commissioners, the latter interview in the presence of his attorney, and that it was then and there agreed that the works at Brentwood were built and operated under the Glover patents, that our company could advertise them as such, that the commissioners could be referred to as to their successful operation, that the works might be visited in our interests, and that the superintendent might distribute to inquirers our literature on the subject.

The Commissioners of Rockingham county state that they never at any time or place, either verbally or by silence, agreed to any part or portion of the above; on the contrary, that they distinctly stated to Mr. McClintock that they did not acknowledge any claim of any kind whatever. And in my presence they instructed the superintendent of the county farm not to acknowledge any such claim to any party who might visit the institution in Mr. McClintock's interest, or to mix or meddle with the package of literature that he left them.

After the filter became clogged, and until the work was reconstructed, the nuisance in the brook was nearly as bad as it originally was. Septic action, if there was any, did very little to improve it. The superintendent, after the pipes became clogged, lowered the invert of the inlet sewer pipe some 18 ins., and when the tank was filled with sludge as far up as the pipe, emptied it. When I reconstructed the work, and laid the pipe to a true grade, I returned the invert to its original height, as arranged by Mr. Glover, so that what Mr. McClintock says about my diminishing the capacity of the tank one-third is without any foundation whatever. The original filter is also exactly the same depth that it was at first. The area which I added is 50% deeper, and gives much better results. This filter is divided into four parts, and so arranged that one or all can be used independent of the others. The Rockingham county authorities, both those now in office and the incoming officers are all honorable gentlemen and also pretty fair samples of shrewd New Hampshire Yankees. They claim to be perfectly willing and ready to square accounts with Mr. McClintock's company on a fair business basis.

Yours very truly, Arther W. Dudley, C. E.
936 Elm St., Manchester, N. H., March 13, 1901.

Notes and Queries.

"H." writes:

The "New Scraping Tool for Dressing Stone" (Eng. News, p. 193) is a slight modification of "la ripe," a tool long used on soft stones in France. "La ripe" has a toothed scraper at one end and a smooth one for finishing in place of the handle shown on the "new" tool. It is figured in "L'art de Construire," Paris, 1850.

BECQUEREL RAYS, named after a French chemist who discovered them in 1895, are said by "Kirchoff's Technische Blätter" to possess properties similar to the Rœntgen rays. Recent experiments at the Berlin High School of Technology prove that the Becquerel rays are not emitted from uranium, but from a new element; and they have the property of making almost every transparent substance luminous in the darkness; thus enabling genuine diamonds to be told from artificial ones in the dark. It is also found that this new element, in large quantities, makes the air such a good conductor of electricity that it is hoped that this property can be utilized in wireless telegraphy.

THE LIVERPOOL SELF-PROPELLED TRAFFIC Association announces that the entry-forms for the competitive trials of June, 1901, are now ready for distribution. Full details of the conditions of the trial were published and distributed last June; but, to permit the entry of a number of vehicles that would otherwise be debarred, a Fourth Class is added. In this new Class D, there are no restrictions upon the tare or platform area; the minimum load to be carried is 4 tons, but an excess may be declared by Rule I. The specifications remain unchanged for Classes A, B and C.

A BOSTON-NARRAGANSETT BAY CANAL PROJECT is again before the Massachusetts Legislature, and $10,000 is asked for for a survey of this canal, by way of Weymouth and Taunton rivers. The Boston "Herald" opposes the scheme—as not new, and as of little use even if constructed. It is assumed that at least two locks would be necessary in such a canal; and if so, a coasting steamer would make better time by going around Cape Cod. As to a shorter route for coal barges from New York, the money saved in time would probably be consumed in canal tolls, and Boston would gain little or nothing, though Brockton and some of the smaller coast towns might have cheaper coal than they can get by rail.

WIRELESS TELEGRAPH STATIONS are to be erected at different points on the Atlantic coast for use in signalling to and from incoming vessels, according to a press report. Some of the vessels of the North German Lloyd Line have been equipped with instruments, but they are, of course, useless on the American coast, where there are no stations. Mr. Marconi is now in New York city for the purpose, it is said, of arranging for the erection of the stations.

THE DECIMAL ASSOCIATION, of England, has made its annual report for 1900. Among the advances in this direction in England are noted the following: The Education Department, in the Code of Regulations for Day Schools, requires that instruction in the principles of the metric system "must be given" to scholars in certain advanced grades named. The Congress of Chambers of Commerce of the British Empire, held in London in June last, resolved that the metric system of weights and measures, as recommended by a Select Parliament Committee in 1895, should be legalized in all parts of the Empire, excepting India; and after two years be made compulsory by Act. And meanwhile the system should be taught in all schools. Negotiations are in progress for bringing about a conference in Paris of representatives of Great Britain, the United States and Russia, with the view of having the metric system adopted in these countries. The report speaks of the growth of public opinion in this direction in the United States and Canada, and says that there is a growing disposition on the part of the Russian government to adopt this system. The report claims that the uniform system of metric dimensions adopted by the Iron and Steel Manufacturers' Unions of Germany, is one of the chief reasons for the preference which Germany has lately obtained over England in the matter of railway material and bridges. It makes no mention, however, of the preference obtained by the non-metric United States in the same direction. The Secretary of this Association is Mr. Edward Johnson, Botolph House, Eastcheap, London.

FAILURE OF BULKHEAD AT DYER DAM, DANIELSON, CONN.

By Ernest H. Brownell, Assoc. M. Am. Soc. C. E.*

The power plant of the People's Tramway Co. is located on the Quinebaug River, about two miles below Danielson, Conn.† The river has a drainage area above this point of from 450 to 500 square miles.

The dam and bulkhead were built in 1879 and 1880, by the Wauregan Co., with the intention of establishing a cotton manufactory, but the project was not carried out, no buildings were erected, nor was any use made of the power.

The dam is 208½ ft. long, between two massive masonry abutments. It was built of cribwork, with stone filling. At its south end was a masonry bulkhead, with seven arches, each 10 ft. wide, with piers each 3 ft. wide. These arches were faced with ashlar masonry. Fig. 1 is a sketch plan of the dam, bulkhead and power house. Figs. 2 and 3 show the dam and wasteway from below. The first two openings, Fig. 1 (counting south from the dam), formed a wasteway, with two gates, each 10 × 10 ft., leading into a single arch of a width equal to the two. The third was closed, and built up solidly within, with a vertical shaft 5 ft. square, probably intended for a small wheel for use in raising the gates, although no outlet to this shaft has been discovered. The other four archways were for head gates, each 10 × 10 ft.

The People's Tramway Co. purchased this property in 1899. Since then they have constructed a power house, with boiler house, and have nearly completed the installation of an electric plant, which derives its power from a hydraulic plant consisting of three horizontal twin turbines of 750 HP. each (under 16 ft. head), and an auxiliary wheel of 80 HP. for driving exciter dynamos,

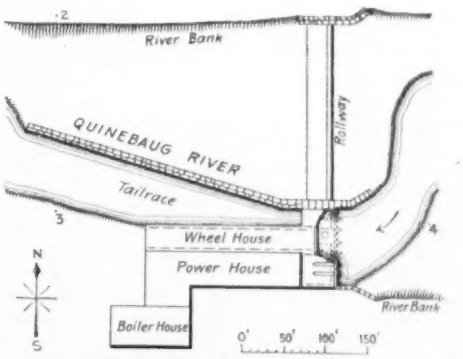

Fig. 1.—Sketch Plan of Dyer Dam and Adjacent Power-House, Danielson, Conn.

(Numerals (2), (3), (4), indicate points from which the views were taken.)

making a total of 2,330 HP. There is also a steam engine of 1,500 HP., the estimated minimum power available from the river being about 1,000 HP. It is a notable equipment, and worthy of a better description than these brief notes.

The general dimensions of the dam were unchanged. Most of the old timbers were pulled out and the dam was covered with concrete, its cross-section being changed somewhat. The abutment walls at the ends were not changed. The height was not increased, remaining 12 ft. There is a fall of 4 ft. between the foot of the dam and the end of the tail-race, giving a total head of 16 ft.

The power is intended for use in operating electric cars, and for the supply of electric light and power. One wheel was started on March 9, for trial purposes. It furnished power for some days.

Early on the morning of March 18 water was observed coming up in the wasteway next to the abutment of the dam (there being no water stand-

*107 Westminster St., Providence, R. I.

†Danielsonville on most maps; the name was changed a few years ago.

ing in this wasteway). About 2:30 p. m. a brick rack-rest extending up stream from the second of the piers supporting the arches fell over to the south. In a few minutes the pier itself gave way, followed in rapid succession by the third pier, and then the first, all before 3 p. m. The fourth pier fell about midnight; there has, apparently, been no further damage. As may be seen from the view, Fig. 4, the two southernmost piers and arches still stand (March 20), as does also the single arch (see Figs. 3 and 4), into which the first two arches opened. The whole flow of the river is through the break and down the tail-race.

FIG. 2.—GENERAL VIEW OF DAM.

FIG. 3.—VIEW OF ARCHED WASTEWAY.

FIGS. 2 AND 3.—THE DAM AND SLUICEWAY FROM BELOW, AFTER FAILURE OF BULKHEAD.

It is to be observed that none of the work done by the Tramway Co. has given way in any particular. Even where it is subjected to the powerful flow of the river in the break, it stands intact, notably at the east end of the wheel room. Where the fourth pier fell, the impression of its edge can be clearly seen in the end of the new wall.

All of the work that failed had stood for over 20 years, but without pressure, being backed by earth.

The cause of the failure was probably in the foundation of the piers. The abutments at the ends of the bulkhead had deep foundations, extending to firm gravel. The piers are said to have extended down only about to the level of the bottom of the present head-bay, the four southerly ones resting on planking, laid on hewed timbers parallel to the dam, with sheet-piling extending from nothing to two or three inches below the timbers; the next one resting on earth, and the one in the middle of the wasteway being on planks.

The new work has its foundations 9 ft. below the level of the lowest water in the tail-race; I should infer that the difference in level between these foundations and those that failed is about 16 or 17 ft.

The first failure was about 25 ft. from the new work, indicating that it was not due to disturbance of the foundations by the new construction.

The water was 18 ins. higher than the rollway of the dam. A week before (March 11) it was 5 ft. 7½ ins. above the rollway.

The rush of water at the time of the accident raised the level of a millpond some two miles down river 9 ins.

There are four timber sluiceways, each 4 ft. square, in the dam, that were used during construction. The concrete is being cut through so that these may be opened again.

It is to be noted that the original design of the Wauregan Co. is said to have contemplated the construction of a long head race, with wheels some 2,000 ft. down river from the dam. The wasteway was to have emptied immediately below the dam.

THE SETTING OUT OF YARD TRACKS.

While the calculations for switch work and turnouts are somewhat complicated, yet for ordinary turnouts the work of setting out is comparatively easy, for the reason that close adherence to theoretical or calculated distances is not necessary. The calculated length of lead may be varied several inches or a few feet without affecting the line or the riding qualities of the turnout, and the switch or frog may be shifted correspondingly to avoid cutting main track rails or for other reasons of practical convenience. In complicated crossings, junctions and yard work, however, as well as in street railway track, very much closer calculations must be made, and adhered to, the closeness and accuracy of the actual measurements being of great importance, as any variation in one part will affect the entire layout. For work of this kind the material must be cut and fitted so that it can be put together and bolted up in the field with the same accuracy as is required for steel bridge work.

In laying out yards, terminal connections and other complicated work, it is best to plot the plan on a large scale, and then take the measurements from the drawing. An interesting case of this kind occurred in the planning of the passenger yard of the new Southern terminal at Boston, for the New York, New Haven & Hartford R. R., where the tracks are unusually complex. A sketch plan of this yard is shown in Fig. 1. The eight straight main tracks develop into 28 house tracks. At the throat of the yard these eight tracks are crossed in both directions by double tracks, these double tracks crossing each other in the middle and having double slip switches at each intersection with the main tracks.

To Mr. George B. Francis, M. Am. Soc. C. E., who was Resident Engineer of the terminal during its construction, we are indebted for the following particulars as to the method adopted in planning and ordering the material for ties, frogs, switches, etc., and in setting out the work. A plan was drawn on a scale of ⅛-in. to 1 ft., upon which was a center base line, with 100-ft. stations, points at right angles to this base line being designated as so much east or west of certain base line stations. This plan was developed to show each tie (and its length), each special timber support for any part of the interlocking apparatus, each switch, frog, guard rail, etc.; the station and distance east or west for each switch point; the frog point apex, point of curve and radius for each piece of curved track; also all signal posts and signal bridge supports, as well as all grades. From this plan all ties and special timbers were ordered, it having been carefully examined for the latter purpose by the signal company. The entire plan was about 24 ft. long and about 7 ft. wide, divided into several sheets, and was upon tracing cloth for purpose of blue printing. All of the calculations for this work were made and checked in the office so that the setting out or staking was such a simple matter that no blunders were made and no other method used in the field than a careful reproduction with the transit and tape of just what was on the plan, using ordinary stakes for line. Later on, when the tracks were raised to grade upon the ballast, grade stakes were set.

The standard layout for ladder tracks of the Michigan Central R. R. is shown in Fig. 2. The angle made by the ladder track with the main line governs the distance between head blocks and frogs, and it is the practice to use a No. 11 frog in the main track for all yard leads whenever practicable. The standard ladder track layout is laid on this basis. In staking out the work, the point of intersection of the center lines of the ladder track and the main track is first decided upon. The location of the No. 11 frog in the main track is a very simple matter. The ladder track layout gives distances from the intersection point mentioned above to the first frog on the ladder track, and also to a point which represents the corresponding point of frog in the first body track. Having located the point of frog in the main track, and the P. C. and P. T. for the short curve connecting the main track lead with the ladder track, the instrument is placed at the intersection of the center line of the ladder track with the center line of the main track. The angle the ladder track makes with the main track is turned off, and stakes for the headblock, point of frog and point of curve are set along the center line of the ladder track, according to measurements given on the plan. It will be observed that the angle

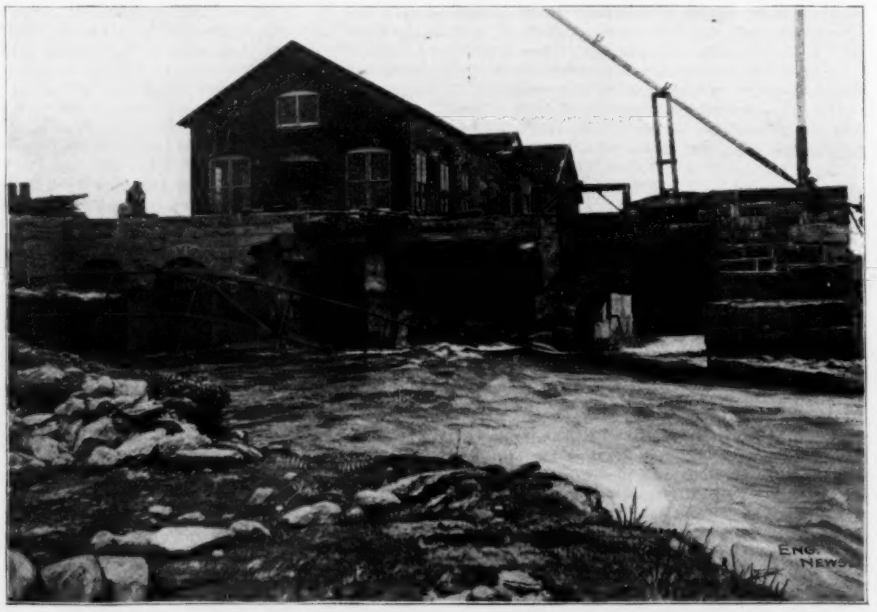

FIG. 4.—VIEW OF WRECKED BULKHEAD FROM ABOVE.

of the ladder track is 9° 1′, laid with No. 9 frogs. The headblocks along the ladder tracks are 83 ft. apart; this distance is made up of the lead, 72.43 ft.; frog leg beyond frog point, 8 ft.; straight track to bend in stock rail, 1.95 ft.; and from this bend to switch point, 0.68 ft. The same distance, 83 ft., governs the position of the point of curve and point of frog stakes with reference to each other. After the necessary stakes are set

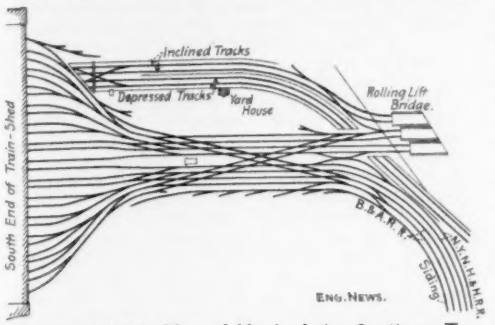

Fig. 1.—Sketch Plan of Yard of the Southern Terminal Station at Boston, Mass.

along the ladder track, the instrument is placed at (D), which is the center of the first body track opposite its point of frog. The angle of the ladder track is turned off from line parallel to the center line of the main track and point of frog stakes set along this line 83 ft. apart. The instrument is next moved to (E), which represents the point of curve connecting the frog angle with the center line of the body track. The angle of the ladder track is again turned off from the center line of the main track and P. C. stakes set along this line. The instrument is next moved to point marked (F), which represents the point of tangent of the above mentioned curve, and stakes are set 83 ft. apart parallel to the ladder track.

It is not the practice to bend the frog leg nearer the point than 3 ft. The blue print shows all the yard tracks 13 ft. apart, but this practice has been changed, and the distance of the first yard track from the main track has been increased to 16 ft. This gives room for the erection of standpipes, signals, etc., between these tracks.

After the headblock and frog-point stakes have been set the foreman in charge of the work lays out the switch according to offset measurements given in the book of "Switch Layouts," compiled by Mr. Torrey, Chief Engineer of the Michigan Central R. R.

Mr. H. B. Dick, Chief Engineer of the Ohio & Little Kanawha R. R., states it has been his practice in all cases, except for ordinary switches, to set out turnouts with the transit; setting plugs for points of switches and points of frogs. He uses Searles' "Field Book" in all theoretical calculations necessary in staking out turnouts, and in the practical work of putting in switches has followed closely the hints given in Lovell's "Practical Switch Work." He has found this book to cover the ground very thoroughly and in a very practical manner, and thinks that a combination of the work covered by this book and a few of the formulas given in Searles' "Field Book" would be all that would be needed in laying out any switch or sets of switches, unless in special or complicated cases.

In working in frogs or switches where shortened leads are used, it is only necessary to be careful in placing the frog point opposite the stake, letting the switch point come where it may. This in no way disturbs the alinement of the track behind the frog. The practice is to use short leads in all frogs above No. 7, and theoretical leads for all frogs less than No. 8. The shortened leads, as given by Lovell, are about as short as should be used in ordinary practice, although in special cases leads have been used for No. 8 frogs which are several feet shorter than those given. For instance, the practice on the O. & L. K. R. R. in laying out a No. 8 switch is to use a 30-ft. rail, a 15-ft. piece, a 15-ft. switch point, and a 15-ft. frog. This gives a lead of 67 ft. from point of frog to point of switch, which is rather shorter than the lead suggested by Lovell. However, it has been found to work very well, and it is economical. For a turnout from a tangent, the short piece is obtained by cutting a 30-ft. rail so as to make one piece 15 ft. 1 in. long and the other 14 ft. 11 ins. Then by using the shorter piece on the straight main track rail and the longer piece on the opposite lead, it brings the switch points square across the track. Should the turnout be from the outside of a curve of 4° 45′ the turnout curve would be the same, and both lead rails would then be the same length. In this case, of course, the 30-ft. rail would be cut to make two pieces 15 ft. long. It would be better practice, however, to use 18-ft. switch points, which would give a 70-ft. lead, which is probably the best lead for a No. 8 frog.

In staking out ladder tracks, after determining the number of frog to be used and the distance between tracks, the formula A = P ÷ sin. F is used for determining the distance between switches. Here A = the distance between frog points, P = distance c. to c. of tracks, F = frog angle. The transit is then used to set plugs for points of frogs and points of switches, using the theoretical lead in all cases. Then all that is necessary in putting in the work to make the tracks conform to the stakes is to be careful to place the frog point opposite its stake, and let the point of the switch come where the shortened lead brings it.

The method of laying out yard tracks on the Lehigh Valley Ry. is to establish the ladder tracks by staking out with a transit, and at the same time to stake out the locations for frog points. The trackmen do the rest of the work. With this exception only one of the standing tracks is usually staked out and the rest are put in by measurements from the first track located. This road is working to a No. 10 turnout entirely, as standard, but for turnouts now in track is using frogs as low as No. 6. In new yards, the No. 10 frog is put in if possible, and the aim is to use nothing less than a No. 8.

In staking out turnouts and spur tracks on the Chicago Junction Ry. it is the general practice to use the transit only where tracks deviate, or run out from main tracks for a considerable distance, or run off on a curve, or reverse outside of and parallel with the main line, at a distance of about 30 ft. or more. No instrument work is required for short tracks that parallel the main tracks and are close to them. In such cases, stakes are set at the frog point, and the reverse and tangent points. In setting off a turnout, the spread from the rail is measured, and the line run out from this on a tangent, or to the intersection of lines, fixing the curve by using Searles' "Field Book" (Table VI., Tangents and Externals for a 1° Curve) for short, easy curves.

The curves are run with the instrument by fixing the P. C. or "point of curve" and E. C. or "end of curve" by measuring the tangent distance from the P. I. "or point of intersection of lines," calculating the tangent distance by the table. This will not bring the P. C. and E. C. absolutely right, especially on very sharp curves. In such cases the points are figured by the usual formula for simple curves: T = R tan. ½ angle. Here T is the tangent distance, or the distance from the point of intersection of straight lines to the point of intersection, and R is the radius of curve.

Example: Find the tangent distance T for a 24° curve with a central angle of 80°. D = 24°, equals R 240.487 (Table IV., Searles). Angle = 80°; ½ angle of 40° natural tangent = 0.8391.

$$240.487 \times 0.8391 = 201.7926 = T.$$

Otherwise by Table VI. (Searles), T for 1° curve, angle 80° equals 4807.7.

$$4807.7 \div 24 = 200.3208 \text{ without correction.}$$

Correction as per Table V. (Searles) = 1.48.

$$200.32 + 1.48 = 201.80.$$

Without the correction as per Table V., the tangent distance would be 1.47 ft. short. Consequently, in running the curve it would not check out on end of curve without using the correction table, making it less work to calculate by formula.

For short curves, end points and center points from the P. I. are usually set, while on sharp curves of 20° and over, stakes are set at 25-ft. intervals. In staking out ladder tracks for yards, the instrument should be used to give the line, and two stakes set for every frog at theoretical point. Stakes are also set for the line of one track in the yard, the foreman spacing in the others.

Ladder tracks should be laid out to the greatest possible angle for the frog used, and the method of arriving at this is given as follows by Mr. Sims, Engineer of Maintenance of Way of the Pennsylvania Lines: Take the minimum length of lead for the frog to be used for the yard, which is the distance from the point of frog to the point of switch. Add to this distance the amount of clearance from the point of frog back to the point of the next switch. With a No. 7 frog the lead is 60 ft.; the clearance distance will be 10 ft., making 70 ft. in all from switch to switch. If the body tracks in the yard are to be laid out 12 ft. c. to c. dividing 12 by 70 will give the natural sine of the ladder angle, as shown in Fig. 3. If the body tracks are 13 ft. apart, substitute 13 for 12.

One of the great advantages of this method is that it puts a little curve back of the frog, which corrects all inaccuracies in laying out the track and makes the ladder look straight and perfect, and all the body tracks swing off from it similarly, while if the exact frog angle is used for the ladder the slightest error in location shows up and looks badly on the ground.

Care should be taken in staking out ladder tracks to first determine the ladder angle, and then to turn it carefully with the transit from

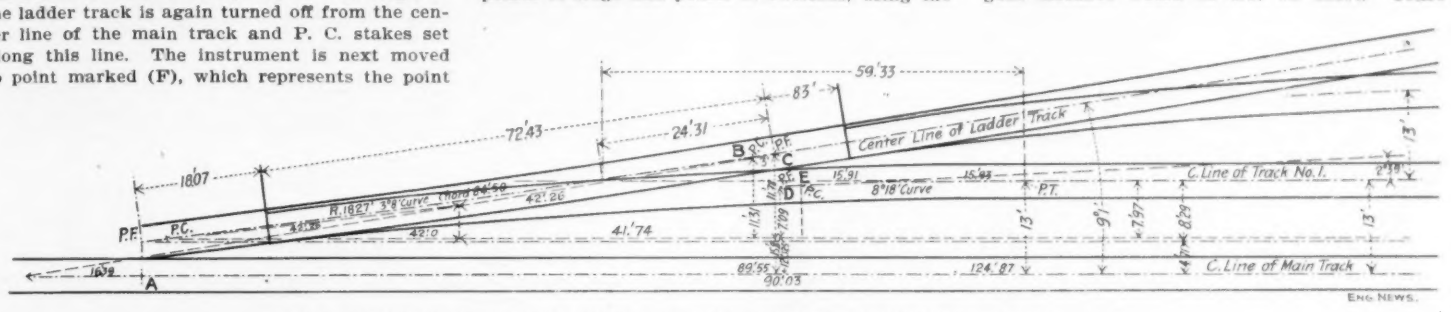

FIG. 2.—STANDARD PLAN FOR LADDER TRACK IN YARDS; MICHIGAN CENTRAL R. R.

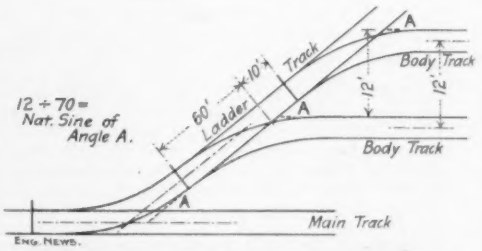

Fig. 3.—Diagram of Ladder Track; Pennsylvania Lines.

the main track or whichever track it switches from, and put in a long line of stakes. On this line the switches should then be located the exact distance apart, which the original assumption called for. By following this out the switches will be the least possible distance apart, which is an advantage. The angle of the ladder will be the greatest possible, which gives the maximum car capacity of the yard for the amount of space occupied. It will also make a yard which will look well. By simple calculation the line of stakes can be run down either the center line of the track, which is preferable, or on the gage line.

SHERMAN HILL CUT-OFF; UNION PACIFIC RY.*

By J. I. Boggs, Assoc. M. Am. Soc. C. E.†

There are many engineers who have only a faint idea of the heavy construction being so generally carried on by the great transcontinental railway lines in their efforts to reduce grades and straighten alinements. Among others, the Union Pacific Ry. has shown remarkable activity in this direction. Its line has been shortened by many miles, and its grades reduced to a maximum of 0.82 of 1%, compensated 0.03 for each degree of curvature, the maximum curvature allowed being 4°. On all new construction everything is being carried out to a perfect working model.

GENERAL DESCRIPTION OF WORK.

The highest summit on this line is at Sherman Hill, an elevation of 8,247 ft. above sea level, situated 33 miles west of Cheyenne, and 23 miles east of Laramie, Wyo. This has always been the bete noir of the transportation department. To overcome some of its difficulties a corps of engineers was placed in the field early in 1899 to locate a line from Laramie to Buford, the latter being a small station 7 miles east of Sherman. Several months were spent in locating the line, the final result exhibiting a large amount of curvature and an irregular profile. The summit, however, was lowered 240 ft., and the maximum grade was obtained by tunneling 3,400 ft. Not until the first part of April, 1900, did the company finally decide to construct, and appointed D. C. Dunlap, M. Am. Soc. C. E., as Resident Engineer in charge of the entire cut-off, with headquarters at Laramie. Under his able supervision the preliminary location was so altered as to reduce the length of tunnel to 1,800 ft., instead of 3,400 ft. He also made other modifications, which reduced the cost materially.

On April 18, the contract to build the line was awarded to Kilpatrick Bros. & Collins, with a time limit of two years, and a bonus if finished in one year (which meant eight months). This firm afterward sublet the greater part of the work, reserving for itself that portion from Station 978, the west portal of the tunnel, to Station 1,098, these 120 stations being the most difficult part of the entire cut-off. Fig. 1. The writer had immediate charge of what is known as the Second Division, extending from Station 898 to Station 1,100, and his remarks will be confined to operations along these four miles, it being the purpose to present as concise a description as possible of the heaviest part of this very heavy work.

The curvature on this division was comparatively light, the maximum being 3°, with a total of 142° 03′ in angles, divided between four curves; but the grading was extraordinary, the quantities being as shown in Table I.

TABLE I.

Kind of work.	Section Nos.— 18,	19,	20,	21,	Summary,
	cu.yds.	cu.yds.	cu.yds.	cu.yds.	cu.yds.
Embankment	81,545	.....	7,225	723,755	812,525
Excavation:					
Earth	3,860	27,215[1] / 27,300[2]	36,391	.....	94,766
Solid granite	13,214	130,330[1] / 105,039[2]	52,569	11,105	312,257
1,800′ tun'l	.....	35,000	.....	.....	35,000
Total	98,619	324,884	96,185	734,860	1,254,548

[1]West tunnel approach. [2]East tunnel approach.

Of the 723,755 cu. yds. of embankment on Section 21, 475,268 cu. yds. were in the fill at Dale Creek, between Stations 1,088 and 1,098. See Fig. 1. The work was divided as follows: Station 898 to 907, Mahoney Brothers, subcontractors; Station 907 to 925, G. C. Smith, subcontractors; Station 925 to 971, Mahoney Brothers, subcontractors; Station 971 to 978, Beaumier Contracting Company, subcontractors; Station 978 to 1,098, Kilpatrick Brothers & Collins, principals; Stations 1,098 to 1,100, Rowan & Scott, subcontractors; Station 1,100 to 1,109, Cushing & O'Keif, subcontractors.

This being on the summit, there was no bridging to contend with, all water courses being taken care of by means of 24 and 30-in. cast-iron pipe, with the exception of Dale Creek, where three lines of 60-in. cast-iron pipe were laid in concrete. This pipe was in 12-ft. lengths, 2½-in. thick, and its weight averaged 1,270 lbs. per foot. Of this 60-in. pipe 936 ft. were placed at elevation 7,749, thus impounding 15 ft. of water for a pumping station, Dale Creek being the only constantly flowing stream, of any amount, on the division. The contractors were fortunate, however, in finding innumerable minor springs of very good water all over the country.

Snow storms were of daily occurrence and the ground was covered with snow from 1 to 6 ft. deep on April 21, when Messrs. Kilpatrick Brothers & Collins began the erection of their camps. One camp was established opposite Station 1,005 and a second on Dale Creek. On April 30 the writer arrived, and found that for two days there had been a violent snow storm. The camps, however, were in good shape and the contractors were ready and anxious to begin work.

PRELIMINARY WORK AND INSTALLATION OF PLANT.

At the outset the contractors had to do much preliminary work; the building of a spur track two miles long for the ready delivery of material, from the main line of the Union Pacific; blacksmith and machine shops to be erected; electric light and compressed air plants, with their attendant wire and pipe lines, to be installed; a shaft for the tunnel to be started at once; nearly two miles of double-track 3-ft. gage railway to be built; a pumping station to be placed on Dale Creek, with a pipe line extending to Station 960; besides many other important items, all demanding immediate and close attention, with not a day's time to lose, as the seasons in this altitude and latitude are very short, the last snow storm having occurred on June 9, and the first of the next season on Sept. 26.

The first efforts at actual construction were directed toward getting a number of teams on the grade between Stations 1,030 and 1,069, and the writer's first duty was to cross-section between these points. On May 1 and 2, in the midst of heavy squalls of snow, the engineer corps cross-sectioned the rock hill dubbed "Spionkop," between Stations 1,086 and 1,088, 50 rock men being started there at once. In the morning of May 4, the east tunnel approach was cross-sectioned from Stations 996 to 1,023, and at 1 p. m. of the same day the excavation was commenced.

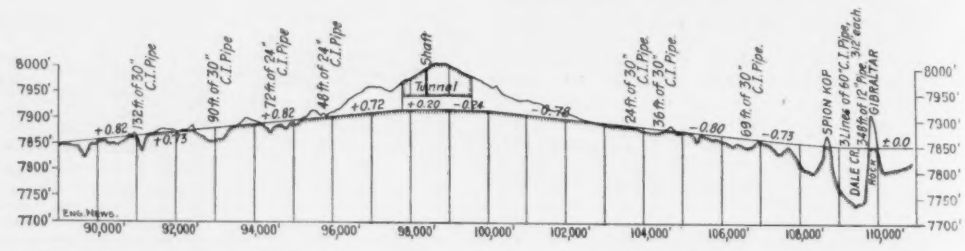

FIG. 1.—PROFILE OF PORTION OF SHERMAN HILL CUT-OFF; UNION PACIFIC RY., WYOMING.

On the following day cross-sections were run from Stations 971 to 978, being part of the west tunnel approach, and work was started immediately after the stakes were driven, in fact, before all were in. At 5 p. m. of this day the first steam shovel arrived. On May 7, the foundations for the electric light and compressor plants were begun, and five laborers, with a foreman, began sinking a shaft for the tunnel at Station 984. On the same day Mahoney Brothers commenced the erection of their camps opposite Station 955. May 15 may be set as the date of the beginning of actual operations, for, although a number of teams had been working on the grade previous to this date, it was not until this day that the steam shovels were started, one being placed in a borrow pit opposite Station 1,060 and about 350 ft. to the south, a second beginning in the east tunnel approach at Station 1,004. At this time the double-track railway was completed as far as Station 1,070.

From this time on, machinery was rapidly put in place, until finally there were in operation eight steam shovels, and 15 locomotives with trains of from 10 to 18 3-yd. dump cars each. The machine drills were run by compressed air, and work was carried on both night and day, the works being lighted by electricity.

DALE CREEK FILL.

From May 15 to June 1, steam shovels and teams were engaged in building the embankment, from Stations 1,070 to 1,085, up as high as the lower level, this level striking "Spionkop," near the 7,825-ft. contour, or 27 ft. below grade. On June 4, a line following this contour as closely as possible was located around the hill for the 3-ft. gage railway, the curves running from 40 to 70 degrees. At Stations 2 + 71 and 4 + 73 on this narrow gage line, split switch points were inserted, and about June 8 the active construction of the immense fill may be said to have been begun, by side-dumping and constantly throwing the track ahead. This side-dumping was continued until about July 19, when, owing to the failure of the foundries to supply the 60-in. pipe promptly, the work on the west side of the creek had to be temporarily stopped. The contractors then commenced filling to the grade line west of "Spionkop." Prior to this, however, a line had been located and constructed on the 7,790 ft. contour, from a borrow pit on the east side of Dale Creek, around the base of "Gibraltar" to the south line of the stakes. Here, one shovel and two trains were constantly pouring in material, in the quadrant of a circle whose radius was the distance between the opposite slope stakes, the track being occasionally lengthened by means of temporary trestles, one of which may be seen on the left in Fig. 2. It was not until July 30 that the 60-in. pipes were in place, and work was resumed on the west side. By this time the bank west of Station 1,086 had been filled to grade, and it become necessary to remove the track from the south side of "Spionkop," disconnecting it at Station 2 + 71 and resorting to filling, in the quadrant of a circle, as was done on the east side. This continued until Station 1,093 was reached, when trestling was used, as shown in Fig. 2. The height of the trestling, however, was reduced 20 ft. by having a number of teams build embankment bases before its construction was commenced. On August 1 the narrow-gage track was laid through the rock cut on the top of "Spionkop," and the first bent of temporary trestle for the upper and final lift was erected. Fig. 2 shows the condition of the work on Sept. 1; "Spionkop" being on the extreme right, the first trestle to the left being to grade, the second 30 ft. below, and the one on the extreme left, coming from the shovel on the east side, 60 ft. below grade. Dec. 1 saw this gigantic bank of 475,000 cu. yds. completed. This fill is to take the place of a bridge on the main line 127 ft. high. The writer did not agree entirely with the foregoing method of construction, as it was productive of much expense, annoyance and delay. He is of the opinion that had a line been built around "Spionkop" on the 7,790-ft. contour with trestling from the first, it would have been found much more expeditious and less expensive; however, he was overruled in the matter at the time, but since then has had the poor satisfaction of having the contractors tell him that they regretted not having adopted his plan.

SHERMAN HILL TUNNEL.

As stated, on May 7, work was begun on a shaft for the tunnel at Station 984, and was continuously prosecuted, night and day, through the solid granite, until on June 13, a depth of 65 ft. was reached, 5 ft. below the springing line of the arch. Here the first difficulties and anxieties of the engineers in charge began, for it now became necessary to set grades and centers for the two headings; one working east, the other west. The writer had no suitable instruments, the best being an ordinary Gurley's plain transit, and a 20-in. level. He also had two 50-ft. metallic tape lines, and two 1-lb. plumb-bobs of cast iron, having points ⅛-in. in diameter. Placing two 3 × 12-in. planks securely over the shaft, two nails were set on center and partially driven. A wire, fastened at each end to the nails, was then stretched across, and the two plumb-bobs were suspended therefrom. Two holes, one on each side, were then drilled 1 ft. above the crown, two wooden plugs were inserted, the plumbs were again dropped and two nails set. For elevation, two metallic tape lines were tied together and the elevation was measured in from a bench set at the edge of the shaft and checked by means of a wire measured to exact length over the level rod. Hoisting engines, gallows frame, and blacksmith shops were soon erected, and in a short time the center line was completely obstructed, so that when the headings were driven about 75 ft. on each side, and centers had to be reset, the first having been blown out, it became necessary to use an offset line. This, the writer disliked doing, owing to the poor character of the instruments at hand; however, it was imperative and he had no choice in the matter. At Station 992, east of the shaft, a right angle was turned and an offset line 60 ft. to the south established, and carefully checked in on a point at Station 982, to see that it was parallel. A point was then established opposite the shaft and a line run across it at right angles to the direction of the headings. Two nails were again set, a wire stretched between and the two plumb-bobs dropped 9 ft. apart. A distance of 55½ ft. was carefully measured to the first and a point set beneath it in the floor of the shaft; the second was allowed to remain suspended as a foresight. Right angles were then turned and an offset line 4½ ft. south of the center was run along the floor of the headings in both directions. For the center, points in the roof were then set from this line, and plumbs suspended from them. For a check, as 3 ft. to the north would clear the obstructions east of the shaft, an offset line at that distance was run across it,

*Abstract of a paper read before the American Society of Civil Engineers March 20, 1901.

†Union Pacific Ry., Laramie, Wyo.

and the two plumbs suspended with 6 ft. between them, a point being taken below one; the other remaining suspended, as before, for a sight. A 3-ft. offset line was run along the floor of both headings, and the points in the roof, previously set, were checked from this. These points checked fairly well, and were thereafter used to prolong the line when necessary.

The operations noted, while simple enough above ground, are very different beneath it, in a small comparatively dark hole, working by candle light, with the clatter of machine drills on all sides, gangs of "muckers" waiting, etc., especially when only very common field instruments are available. Unless the engineer in charge has a cool, clear-headed instrumentman he is likely to experience considerable trouble where the headings meet.

On one occasion, the instrumentman decared that nothing more could be done, as the cross-hairs had slackened so badly, from the surrounding moisture, that he could not set a point within ¼-in. Something more had to be done, as it was imperatively necessary to set a center ahead; so, in desperation, the writer picked up a couple of candles and placed the flame under the diaphragm of the cross wires. This dried and straightened them up, and, with occasional applications of the candle flame, the work proceeded.

On July 6 the heading east from the west portal at Station 978, was started, and on Aug. 23, at Station 981 + 37, it met the heading being driven west from the shaft. The center line was then carefully checked up and was found to be exactly correct at Station 984, at the bottom of the shaft; while, where the two headings met, it was found that the line from the shaft was precisely 1 in. too far north, showing that a slight angle had been obtained in dropping the plumbs.

On July 26, the heading west from the east portal was started and continuously driven night and day until on Dec. 8, at Station 988 + 37, it met the heading driven east from the shaft. Work on the latter heading had been stopped on Sept. 26, after being driven 437 ft. At that time the force was put on the bench. The entire time occupied in driving the headings is shown in Table II.

TABLE. II.

	Days.	No. of ft. driven.	Average rate, in ft., per day.
West portal	49	337	6.88
West shaft	72	263	3.65
East shaft	106	437	4.12
East portal	139	763	5.49
Totals and average	366	1,800	4.92

Usually, six drills on three columns were worked in the headings, the cut being drilled 8 ft. and the round 10 ft. The most difficult and treacherous rock encountered was between the shaft and the west portal, and all this part will have to be timbered; while from the shaft to the east portal the material was very firm. The bench was taken out in two lifts, and the progress has been as shown in Table III.

TABLE. III.

	Days.	No. of ft. driven.	Average rate, in ft., per day.
West portal	92	373	4.06
West shaft	91	227	2.49
East shaft	97	453	4.67
East portal	51	180	3.53
Totals and average	331	1,233	3.73

Much time was lost between the completion of the heading and the starting of the bench at the west portal, as the entire heading had to be slowly and carefully timbered. As shown by the foregoing figures, 567 ft. of bench yet remain to be taken out, between the shaft and the east portal; this, at the present rate of progress, will require about 70 days' more time. It is hoped, however, that this estimate will be materially reduced.

The forces employed in driving this tunnel, so far, reduced to a unit of one day, together with the wages paid, are shown in Table IV.

TABLE IV.

	Force, reduced to unit of 1 day.	Wages paid per day.
Drillers	7,230	$3.25
Drill helpers	8,710	2.25
Muckers	19,980	2.25
Foremen	1,236	125.00*
Total of all classes	37,156	

*Wages paid per month.

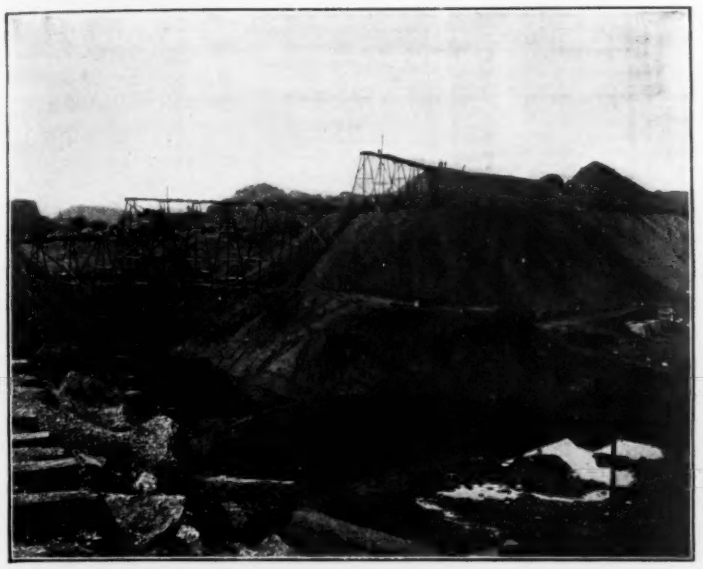

FIG. 2.—VIEW SHOWING METHOD OF MAKING DALE CREEK FILL, SHERMAN HILL CUT-OFF; UNION PACIFIC RY.

No water, of any amount, has been encountered. Fig. 3 illustrates the method used in hoisting muck at the west end; it being then run out to the waste bank by cars. The framework on the right is the dumping frame for the skips. At the shaft the muck was hoisted in cages, in 1-yd steel cars, which were run out on the waste bank and dumped. At the east portal, track was laid in as the work progressed, and the muck was run out through the east approach, and wasted.

FIG. 3.—VIEW SHOWING METHOD OF HOISTING SPOIL FROM WEST PORTAL OF SHERMAN HILL TUNNEL.

PROGRESS OF WORK.

On May 22 Roman & Scott, with a force of eleven men, about all that could be worked to advantage, began excavating the deep rock cut at the hill dubbed "Gibraltar." This was a peak of solid granite, 70 ft. above the grade line at the highest point. Operations commenced by running a 3 x 4 ft. tunnel along the center line and at grade for 50 ft. An ell, 20 ft. long, was then drifted to the north, and charged with 8,750 lbs. of powder. This excavation was completed on November 1.

On May 24, Cushing & O'Keif began on their 110,000-yd. embankment, 900 ft. long, and finished it on Oct. 20. On June 16, the Beaumier Contracting Co. started on their 60,000-yd. excavation, 86% of which was solid rock, and finished it on Dec. 31. On May 10, Mahoney Bros. started on their subcontract, and will probably finish in February, 1901. Nearly all their excavations have been through the very hardest granite, and considerable difficulty has been encountered in moving it, on account of the immense amount of drilling necessary before the steam shovels could properly handle it. All the shallow excavations between Stations 907 and 925 consist of hard granite, and the roadbed being 47 ft. wide, on account of side tracks, made it very difficult; however, it was well handled. On July 31 Mr. Smith began by drilling holes 4½ and 5 ft. apart all over the surface, and on Oct. 15 had finished the entire eighteen stations. Out of 1,250,000 cu. yds. to be moved on the 4 miles, only 12,000 cu. yds., exclusive of the tunnel, remained on Dec. 31, 1900.

The specifications admitted of but two classifications, "Earth" and "Rock." All that could not be ploughed with a No. 1 breaking plow and six horses had to be classed as solid rock. To draw the line between the two was sometimes very difficult.

The writer does not claim anything extraordinary about this work, except the wonderfully short time in which an immense amount of railway grading can be accomplished with modern appliances and methods under difficult and discouraging conditions. One of the greatest annoyances to which the contractor is subjected in this section is the worthless, thriftless class of men he has to depend upon for labor.

Sections 18, 20 and 21 were entirely finished on Dec. 31, 1900, and final estimates were rendered. On Section 19 Mahoney Bros. still have about 12,000 cu. yds. to move and some sloping to do. Beaumier has to do some slope trimming, and not quite one-third of the bench in the tunnel has yet to be moved, while in the east approach about one-half the slopes have to be trimmed up and the cut ditched—the latter being difficult, owing to the frozen condition of the ground. A profile of this division is shown in Fig. 1. From the start to the present time the forces, reduced to a unit of one day, have been as shown in Table V.

TABLE V.—Contractors.

	G. C. Smith.	Mahoney Bros.	Beaumier Contracting Co.	Kilpatrick Bros. & Collins; Wood Bros.	Roman & Scott.	Cushing & O'Keif.
Foremen	230	1,046	704	6,854	203	240
Laborers	2,115	13,710	10,354	50,922	1,117	1,957
Drillers	385	1,850	527	7,625	307	.....
Machinemen	116	1,712	1,364	19,243	.....	.....
Trainmen	.....	1,488	.....	7,263	.....	.....
Total men	2,846	19,806	12,949	91,907	1,627	2,197
Teams.						
Scrapers	928	1,016	452	4,854	9	2,952
Carts	134	.....	.....	.....	216	.....
Plows	144	235	77	610	.....	295
Wagons	.....	305	.....	520	.....	.....
Cars	.....	24	830	1,521	.....	107
Totals	1,198	1,580	1,368	7,505	225	3,354

A NEW SUBAQUEOUS VIADUCT.

In our issue of Dec 13 last, we published a letter from Mr. J. T. Ford, M. Inst. C. E., calling attention to a recent newspaper description of a "subaqueous viaduct," and referring to his own early work as an inventor in this field, as de-

scribed in Engineering News of April 11, 1891. The projector of the new subaqueous viaduct, Mr. F. W. Fitzpatrick, of the U. S. Treasury Department, Washington, D. C., has since that date furnished us full information as to his plans. He states that he and his associates have secured control of several important early patents in this field, among them one by Strom, Hilliker & Lindman (No. 439,610). The Strom viaduct was illustrated

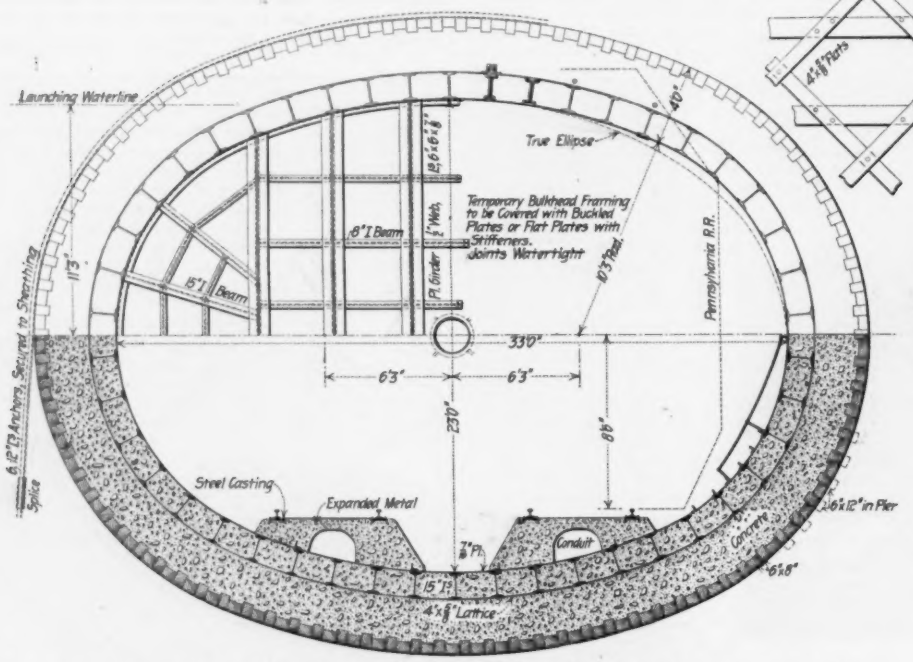

FIG. 1.—TYPICAL SECTION OF PROPOSED SUBAQUEOUS VIADUCT FOR DOUBLE-TRACK ELECTRIC RAILWAY ACROSS THE NORTH RIVER, NEW YORK CITY.
F. W. Fitzpatrick, Inventor; Fred. W. Lepper, Assoc. M. Am. Soc. C. E., Chief Engineer.

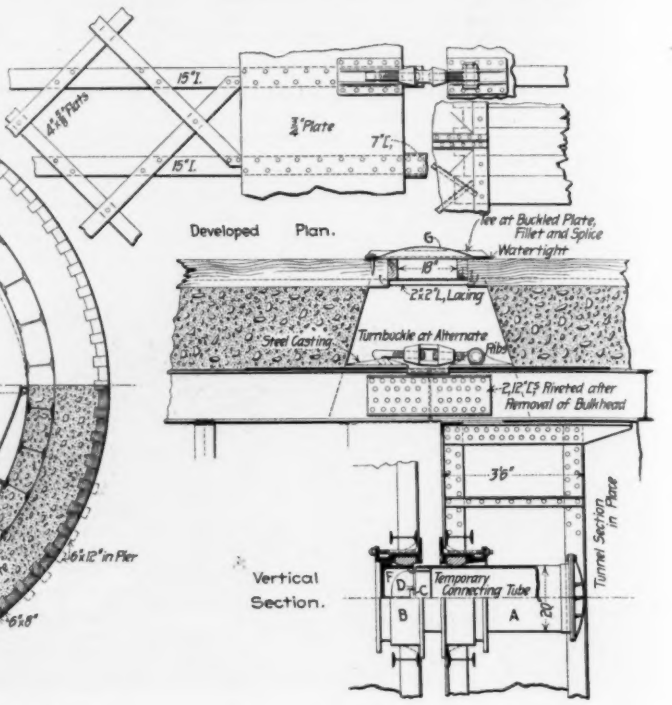

Fig. 3.—Detail of Splice at Junction of Viaduct Sections.

and described in Engineering News, volume Jan.-June, '91, p. 198. These patents and inventions have lain dormant until very recently, when Mr. Fitzpatrick has taken them up and interested capitalists in their promotion and practical application, and a company is shortly to be organized to construct subaqueous viaducts upon the plans developed by Mr. Fitzpatrick and his engineers. It is stated that the first of these constructions for which negotiations are likely to be closed is a double-track railway line across the North River at New York city.

At our request, a description of the engineering features of this proposed submarine viaduct has been prepared by the engineer, who has worked out the practical details of this system, Mr. Fred. W. Lepper, Assoc. M. Am. Soc. C. E., and we present it with the accompanying illustrations, as follows:

In general the tunnel consists of a huge pipe built on land (or in a dry dock) in 300 ft. lengths, launched, towed into position, sunk and coupled. While cheaper than a bridge for almost any locality, one of its principal virtues lies in the fact that it may be used to span navigable waters where a bridge would be barred on account of its obstruction or great cost, or in cases where it would not be possible to build a bridge. By placing the tube say 40 ft. below mean low water it will be out of reach of all wave action, the requirements for navigation will be met and the approaches will be short. The depth of water below the tunnel is of little importance, it being laid in a trench for shallow places, on piers for medium depths and simply anchored in deep water. The figures of cost given below, being based upon an assumed condition of bottom, make no distinction as to the different systems of setting, all being regarded as of about the same expense.

It is also to be noted that the tube may be made of such weight that its bearing, due to dead or buoyant load, will be constant, either on piers or anchors—or in fact on both to the extent of one-half of the live load.

For the anchor system, evidently a constant upward pressure is necessary, a portion of the weight of concrete being placed in the anchorages instead of on the tube; it is perfectly stable, however, in currents so long as the width of anchor base and the buoyancy are adjusted to throw the resultant of the latter force and that of the current between the points of anchoring. The torsional moment from a single train load is also amply taken care of by a buoyancy equal to two train loads, while with the other two systems the twist is resisted in the piers or bedding.

In the cases of the trench and short piers, the medium weight tube will work to best advantage, and is so shown by Fig. 1, though the section is perfectly general for all tunnels with the exception of a varying thickness of concrete, and the wood sheathing which may be omitted in the trenches.

The various portions of the general elevation, Fig. 2, are typical of the different systems of setting rather than suggestive of a design for any one tunnel, though the section (e f) gives a fair idea of the construction to be met with at the "Narrows."

Section c d shows a combined pier and anchorage for the medium-weight tube, the pier being heavy enough to counteract the buoyancy of the tube, while section a b is an evolution from the former. Of course, other systems of anchoring may be used to suit conditions.

The tunnel stresses are figured as for a continuous girder of twenty spans, with end bays fixed, with a uniform load, and as six spans when partially loaded, train loads being assumed at 5,000 lbs. per lin. ft., or a total buoyant load of 10,000, plus enough to give stability for a light-weight anchored tube when empty, the full load of two trains for the heavy tube, and plus or minus 5,000 lbs. for one of medium weight.

The steel framing only is depended upon to resist the bending moments, and the section is made constant for both the 10,000 lbs. and 5,000 lbs. loading, because of the reversed stresses from the latter. The matter of impact may, of course, be neglected. The office of the concrete covering is to take care of the water pressure of about 10 tons per sq. ft. maximum, supply the necessary solidity and weight, and a means of adjusting the latter, each inch in thickness varying the effective weight some 800 lbs. per ft.

The moment of inertia of the steel is figured as for an ellipse of thin section, the metal being assumed to act on the line of the centers of gravity of the elements composed of a beam and its portion of inner plate, giving a net maximum fiber stress of 11,000 lbs. per sq. in.

The maximum deflection for the full or partial loading of 10,000 lbs. is ⅝-in. per lineal 100 ft., and but little for the medium-weight tube with loading of ± 5,000 lbs.

Out of deference for the concrete, the splices of the steel framing are of nearly the same strength as the remainder of the tube, but are placed at about the points of contraflexure as an additional precaution and for convenience in setting, the maximum moments at these splices being less than a third of those at the piers, and the other stresses being amply provided for. Excepting for the 70 ft. adjacent to the piers, the uniform section gives a considerable excess of metal, but it is probably as light as can be well used to distribute the local loads in all directions, and the great practical advantage of the simpler construction will no doubt compensate for any small saving which might be made by a varying section.

The outside lattice affords resistance to the torsional stresses, as well as general stiffness and a bond for the concrete. The rails are cushioned on asphaltum and their foundations are similar to

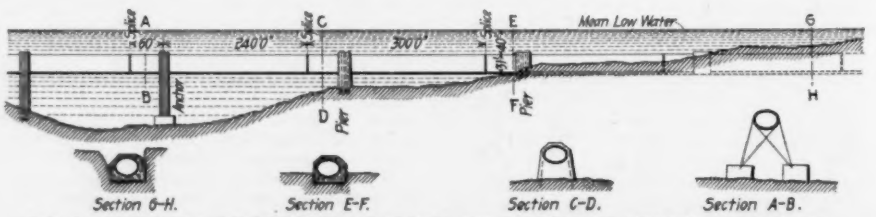

FIG. 2.—METHODS OF SECURING VIADUCT IN DIFFERENT DEPTHS OF WATER.

those discussed in Engineering News some months since.

As above noted, the tunnel is built upon ship's ways in 300-ft. sections complete, and a temporary bulkhead made up of plate girders and covered with watertight plating is fitted into either end, as shown by Figs. 1 and 3. One of the bulkheads is provided with a stuffing-box, B, into the gland of which is screwed a plug, F; the other bulkhead has a similar stuffing-box and a temporary connecting tube, A.

The whole mass is then launched and sinks to the level marked "Launching water line," after which it is towed into position over where it will rest. Only enough water is then admitted to allow the tube to settle gently and be readily handled by floating derricks, etc., and as it is drawn into proximity to the last section set, the tube, A, of the latter section, handled by suitable jacks and framing, is entered into stuffing-box, B, until the lugs, C, engage those at D, by which time the turnbuckles, E, will have been engaged and partly tightened by divers, and the whole new section approximately adjusted.

The plug, F, is screwed out of its stuffing-box, while tube A enters and affords a means of communication after the removal of the inner bonnet. The tunnel section being set is then brought into exact alinement through the center opening, and the turnbuckles screwed tight. The pier or other support, near the farther end of the section, is then completed, and as soon as the buckled plate cover, G, is secured the water is pumped out of the new section and the bulkheads removed. The connection is finished by drilling for the splicing channels, riveting them, filling in concrete, tap bolting interior plates, etc. Of course, it is expected to use the most modern tools and workmanship, and doubtless many of the details will be modified, one possibility being the construction of the tube entirely of expanded metal and concrete.

Aside from the protection from water afforded by the calked wood sheathing, an extensive use of asphalt, asphaltic concrete and other water-proofing materials will be made.

There is nothing unusual about the construction of the piers excepting that a caisson has been designed in halves to fit around the tunnel, though in the majority of cases, after a trench has been blasted or dredged, concrete in bags can be easily laid to form the supports, or the whole tube may be so buried in concrete, where the trench is of considerable depth.

The tunnel will be lined with glazed tile, and be thoroughly ventilated and lighted.

The cost of completing the double track tube across the North River, exclusive of right of way for approaches, is estimated to be about $2,000,000; itemized per 300-ft. span, with its proportion of temporary work as follows:

Steel	$42,500	Setting	$5,000
Piers or trench	12,000	Incidentals	5,000
Concrete	26,000		
Wood	5,000	Total per span.	$95,500

THE DEVELOPMENT OF THE INCLOSED ARC LAMP FOR STREET LIGHTING.*

By Henry M. Humphrey.†

It is evident to any one at all observant that the recent developments in street illumination are in the direction of a uniform and diffused light, rather than along the well-beaten path of previous years which gave brilliantly lighted crossings and Egyptian darkness in the middles of the blocks. The development of the inclosed arc lamp and the growth of mantle gas lighting are illustrations of this point. Some cities still cling to the old-style open arc lamp; notably the city of Chicago, which is still making all its increase with this type of lamp, and the city of Denver, Colo., which is at present installing a new city lighting plant using open arcs for all but one of the circuits. It is reported, however, that this feature of this contract may be changed before the plant is completed and inclosed arc lamps installed throughout the city.

The question of the candle power of the lamp itself is one of importance, but is evidently not a "paramount issue." The old-style direct-current series open arc lamp is without doubt superior in actual candle power to any of the latter types of inclosed lamps. Nevertheless, it is giving place very rapidly to inclosed arc lamps of either the direct current or alternating current type. Development along the lines of electrical progress is not always made in the interest of the public, or of the users of light. Many systems, improvements, etc., are developed by the manufacturing companies for the sole purpose of making an increased market for their goods. This development in arc lamps, however, passing from the open lamp to the inclosed lamp, is one that directly benefits the public and the user of light. Admitting that the candle power is considerably less, for the same expenditure of energy in the lamp, the light is so much easier on the eyes in the immediate neighborhood of the lamp, and the illumination is so much more uniform, that the result is far superior.

A comparison of candle powers between the direct-current open arc, the alternating-current inclosed arc and the direct-current inclosed arc lamps, is somewhat uncertain, owing to the different methods employed by different observers and to the different standards of light used. In fact, the result of candle-power measurements of arc lamps has been so uncertain that very few authoritative data upon this subject have been published.

In Fig. 1 a series of curves, prepared by Mr. H. H. Wait, of Chicago, and presented to the Northwestern Electric Association, is reproduced here by his permission. No. I represents the direct-current open arc lamp; No. II, the direct-current inclosed arc lamp with clear inner globe; No. III, the direct-current inclosed arc lamp with alabaster inner globe and with reflector; No. IV, the alternating-current inclosed arc lamp, with alabaster inner globe and with reflector; No. V, the alternating-current inclosed arc lamp, with opal inner globe and without reflector.

These curves show very decidedly the sacrifice of maximum illumination, in one direction, in order to secure a more uniform distribution of light and a better average illumination.

It is almost universally conceded that the direct-current inclosed arc lamp produces more light per watt than the inclosed alternating-current arc lamp, but the exact ratio between them has not, to my knowledge, been determined. The best data that I am able to find are the tests made by Prof. C. P. Mathews, of Purdue University, under the direction of the Committee on Arc-Light Photometry of the National Electric Light Association. His tests are based on constant-potential lamps, instead of upon series lamps, and his watt measurements are taken across the lamp terminals instead of across the arc only. He has tested eight direct-current inclosed arc lamps and seven alternating-current inclosed lamps, made by different manufacturers. The average difference in candle power between the direct-current lamps and the alternating current lamps is 30%, the average difference in watts consumed at the terminals of the lamp is 27%; the difference in watts at the arc is 12½%.

Taking one particular case, comparing the performance of a direct-current 558-watt lamp, with no outer globe and no shade, with a 418-watt alternating-current lamp, with shade, gives a difference of 39% in light in favor of the direct-current lamp at an expenditure of 23% more power in watts. There is apparently but slight difference between the efficiencies of these lamps when the watts across the terminals are considered.

His data also give the watts at the arc in each of these lamps. The average watts used by the D. C. lamps are 529, of which 384 are available in the arc, and 144 or 27% are wasted in the dead resistance and in the mechanism of the lamp. The average watts used by the A. C. lamp are 417, of which 342 are available in the arc and 74.5 or 18% are wasted in the mechanism. If we reduce the results obtained, to the basis of light produced by watts in the arc, we find that the difference in candle power with the same expenditure of energy in the arc is approximately 16% in favor of the direct-current lamp. The average current for the direct-current lamps was 4.90 and for the alternating-current lamps 6.29.

Fig. 2 shows two curves from his data for 450 watts-in-the-arc arc lamps. In this figure, curves 1 and 2 are for the derect-current lamps; curves 3 and 4 are for the alternating-current lamps. These are approximations only, since the candle power of the lamp varies greatly with different makes of carbons and with different current densities in the arc. These curves can be considered as approximating closely the conditions in series inclosed lamps, since in this type of lamp only 3% of the enegy is used in the mechanism of the lamp.

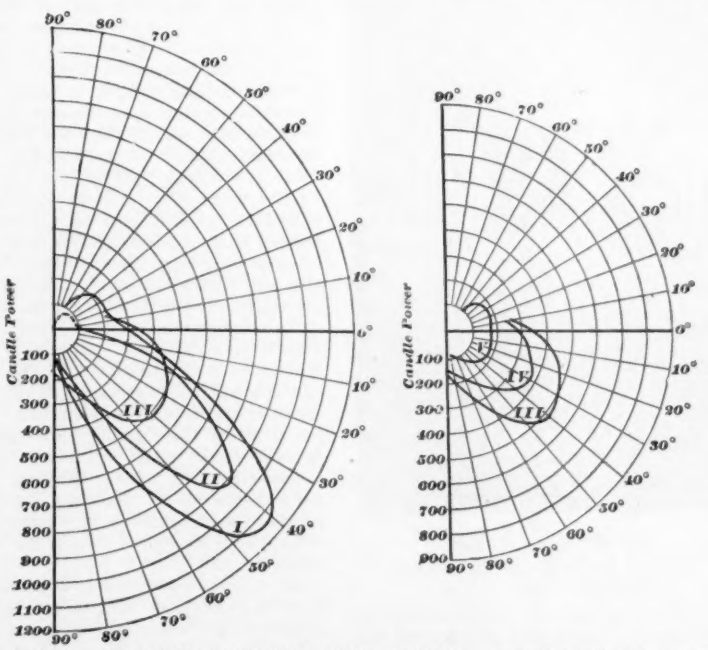

FIG. 1.—DIAGRAMS SHOWING CANDLE-POWER MEASUREMENTS OF VARIOUS FORMS OF OPEN AND INCLOSED ARC LAMPS.

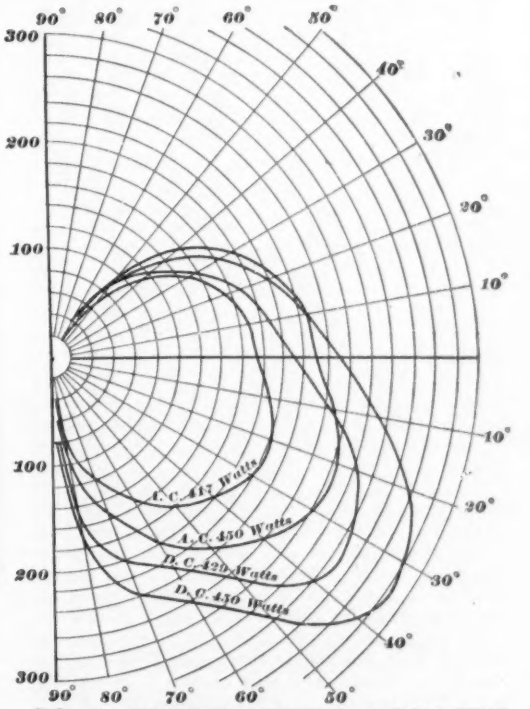

FIG. 2.—DIAGRAMS SHOWING COMPARATIVE CURRENT CONSUMPTION OF OPEN AND INCLOSED ARC LAMPS.

*Extract from a paper read before the Engineers' Club, of St. Louis, Nov. 21, 1900, and published in the Journal of the Association of Engineering Societies for January, 1901.

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THE SECOR INTERNAL COMBUSTION ENGINE.

By John A. Secor.*

The Otto patent having expired, the stimulus of competition during the last decade has caused the gas engine to advance from a partly tentative to an assured position among power generators. The advantages of the internal combustion engine are so obvious that its advocates seemed justified in making the prediction that a further increase in fuel efficiency, and a sufficient increase in engine power would enable the gas engine to assume the leading place as a source of power.

A notable increase in fuel efficiency has been accomplished; the 17% of 1880 has increased to 25½% in 1900, and the small gas engine of the former date has increased to a unit of 1,000 HP.

There can be no question that in the matter of fuel cost gas engines below 20 HP. using illuminating gas as a fuel will ordinarily compete with steam engines of their own size, and large engines using such local fuels as natural gas or blast-furnace gas show that the superior economy as well as efficiency of the gas engine over the best steam engine cannot be disputed.

Yet, notwithstanding the increase in efficiency and size of the gas engine, the steam engine continues to retain the position it has held for a century as the greatest prime mover.

A recent writer believes that the comparatively slow introduction of the internal combustion engine, notwithstanding the advances named, is largely due to prejudice on the part of the user. He remarks: "Whatever prejudice may have existed among power users has been due largely to a lack of knowledge of the construction and operation of the gas engine and to a lack of reliable data as to economy, efficiency and regulation." A careful investigation of the present status of the gas engine, however, reveals the fact that it has certain disadvantages as a power generator, for which no possible increase in fuel efficiency would be an offset. These disadvantages are not usually considered in thermodynamic tests, or mentioned in the catalogs issued by builders.

The same issue of the well-known technical paper which expressed the opinion that power users had an unfounded prejudice against the internal combustion engine, contained an excellent article descriptive of the gas engine exhibit at the Paris Exposition. In the course of the article the writer remarked, in describing a three-cylinder gas engine: "If one cylinder for any reason refuses to operate, *as gas engines have at times an unfortunate habit of doing*, the machine can continue to operate by means of the other two, etc."—the italics are ours.

Without stopping to discuss whether such statements in its news columns would in part account for the "prejudice" which the journal editorially deprecates, we submit that no prime mover which is difficult to start or balky in operation or less reliable in any respect than the steam engine will ever take its place.

It would be an unwarranted assumption to suppose that gas engine builders are not familiar "with the construction and operation of gas engines," yet we find that the steam engine is frequently being used for power in gas engine factories, although the coal consumption would be reduced by using gas engines in connection with gas producers, which in more than one instance are installed on the premises.

Academic opinion, considering the subject from the thermodynamic view point, has insisted hitherto on increased fuel efficiency as the one great desideratum. Prizes have been awarded at exhibitions, where the sole point considered was fuel efficiency. Even at a horse show prizes are not always given for a single feature. A highly specialized engine showing improvement in one or more points obtained at the sacrifice of other important qualities will not be commercially satisfactory. The power user, even when he happens to be a gas engine builder, will usually decide that "steam engine reliability" should be included among the indispensable qualities.

Another obvious disadvantage of the gas engine is the fuel limitation. The necessity for a special fuel, usually costly, and sometimes not obtainable, has been a serious hindrance to the adoption of these engines. An important advantage of the steam engine is its flexibility in the matter of fuel. Every known form of combustible, gaseous, liquid and solid, is being used for the generation of steam. Natural gas, like water power, is valuable but local. Illuminating gas is available only for small engines located in cities. When the gas engine is adapted to use low cost fuels which are everywhere obtainable its usefulness will be greatly enhanced.

Another practical defect in these engines is imperfect speed regulation. An object lesson illustrating the difference between steam and gas engines is shown in an installation where the dynamo is driven by a three-cylinder gas engine, a flexible coupling being used, with a flywheel on the dynamo itself. It is not necessary to enlarge upon this very unpleasant feature, inasmuch as the poor governing incident to gas engines has frequently caused the purchaser to decide in favor of steam.

Summarizing some of the reasons which it is believed influence power users to prefer steam engines to gas engines, we find that gas engines are not usually equal to steam engines in reliability, fuel flexibility and regulation.

As minor drawbacks it may be added that internal combustion engines are larger, heavier, and therefore more expensive to build and require more frequent repairs than steam engines; also that their operation is sometimes accompanied by excessive vibration. Improvement in any of these points would add greatly to the value of the engine. Considering the subject from the purchaser's point of view, it is evident that a commercial engine must include a number of important features, these inter-related features being so harmoniously combined as to produce as nearly as possible a perfect result. In view, however, of the field already occupied by the gas engine, which is due entirely to the continuous improvement and inherent advantages of these engines, it is believed that if all the inferiorities were entirely eliminated, the engine which needs no boiler or fireman would gain the supremacy as a prime mover over all contestants, inasmuch as the ultimate arbiter will be neither prejudice or sentiment, but commercial availability.

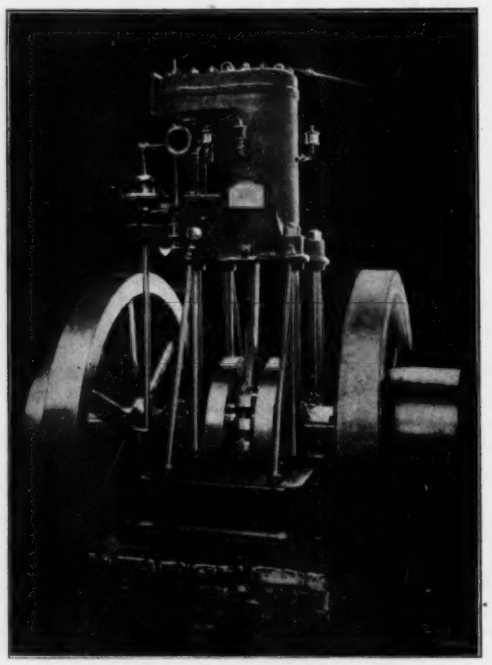


Fig. 1.—25-HP. Secor Engine.
Built by the General Power Co., 100 William St., New York City.

The Secor engine was the result of an attempt to provide an "all around" motor. It was desired to retain the best features of the steam engine in combination with the thermodynamic advantage of the internal combustion engine. In order to obtain steam engine results, it was thought well to adopt steam engine mechanism and methods as far as practicable.

In designing the engine it was intended to produce an easily started, smooth running, absolutely reliable engine capable of using such safe low-cost fuels as may be obtainable, either gas or liquid, with chemically correct combustion and to have such automatically close regulation as would show steady electric pressure when a single cylinder engine was direct connected to a dynamo with a continuous shaft, all gas engine makeshifts being eliminated, and while reducing size and weight of engine to increase the strength and durability.

The Beau de Rochas cycle was employed, using electric ignition. Steam engine poppet valves were adopted, operated in the larger sizes by spiral gears and by spur gears in the smaller sizes, the governing being effected by varying the charge instead of omitting working impulses. In order to retain the requisite fuel flexibility it was considered desirable that the same engine should be readily adapted for using either liquid or gaseous fuel. As already stated, natural gas, wherever obtainable, is the ideal fuel in a gas engine, but producer gas is always available. Any combustible that can be used in a steam boiler can be used if necessary for making producer gas. There is no difficulty in obtaining a brake horse power from a pound of anthracite coal in a good gas producer. Engines of medium or small size, however, require some form of ready prepared fuel, obtainable in every locality or easily shipped. It should be safe and low in cost, while high in thermodynamic value.

Commercial kerosene oil is the only fuel which fulfils these requirements. In fact its potential energy is greater than that of any other medium for storing power. The various advantages of oil as a fuel are well known, but the great difficulty in obtaining perfect combustion under varying conditions has led to the use of gasoline, which is totally unfitted nevertheless for fuel purposes, as it is inferior to kerosene in every respect, being lower in thermal units, higher in price, dangerous to store or handle and in many localities unobtainable. Automobile owners using gasoline are unpleasantly aware that the United States government regulations prohibiting the transportation of gasoline vehicles on ferryboats, as well as the various state laws and underwriter's restrictions, greatly add to the inconvenience resulting from the annoyances already named. Stationary engines in isolated districts are still using this unsuitable fuel as the best substitute for gas.

Those who are familiar with the development of the internal combustion engine are aware that two widely differing systems of feeding liquid fuels have been attempted. In one of these methods the air is compressed about eight times as much as in ordinary gas engines, the fuel is then pumped into the cylinder in the presence of large excess of air which attains a sufficiently high temperature to cause ignition. In the other method the oil is vaporized by heat in an external chamber called a vaporizer; it is then drawn into the cylinder as a gas and compressed with the air.

Oil engines constructed according to either of these methods are much larger, heavier and more expensive to build than ordinary gas engines of equal power. As an example, a well-known firm in England exhibited at the Paris Exposition a gas engine 15 ins. diameter of cylinder by 24 ins. stroke, and also an oil engine of exactly the same size cylinder. The gas engine developed 80 HP., while the oil engine developed only 40 HP. An analysis of weights of various makes of gas and oil engines appears to show that oil engines are ordinarily about twice as heavy as gas engines. It has not been shown thus far that oil engines are more reliable or govern better than gas engines; in fact, it appears to be impracticable to obtain close regulation with liquid fuel where injected by a pump.

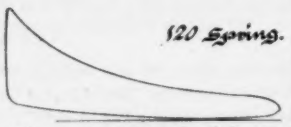


Fig. 4.—Indicator Card from Secor Engine (one-half size).

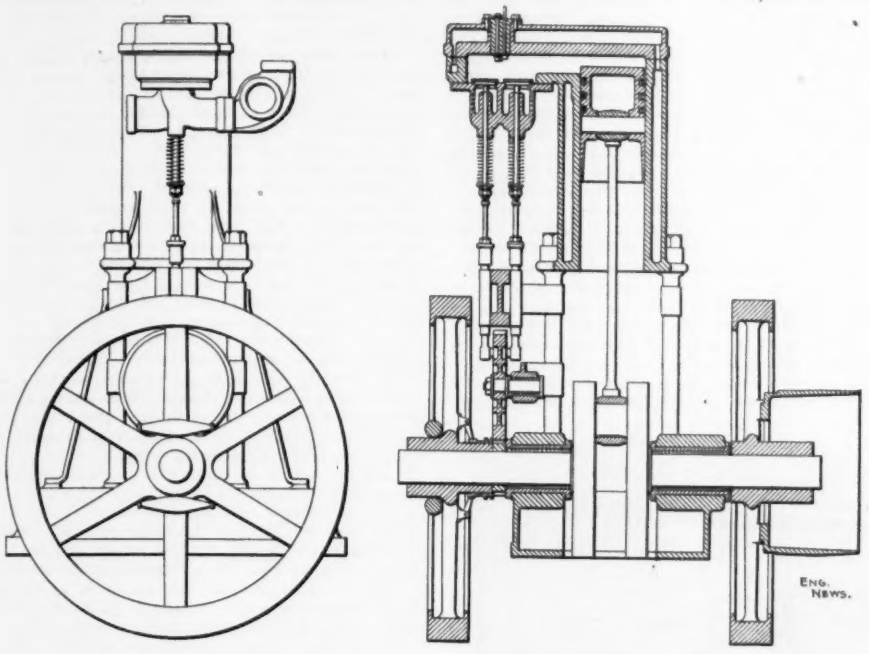
Experience has demonstrated that the problem of using safe oils satisfactorily is not solved by

*100 William St., New York city.

the vaporizing attachment, inasmuch as it tends to increase the uncertainty incident to "force pump" fuel regulation, and the constantly changing conditions render perfect combustion impossible. The unavoidable drawback connected with the use of vaporizers is the fact that in vaporizing the oil its temperature and that of the air mixed with it must be raised to 275° or 300° F. while at atmospheric pressure. This results in two highly unfavorable conditions, viz., the specific gravity of the charge is reduced greatly, so that a given volume contains fewer heat units than if it were at or near atmospheric temperature, and the initial temperature of compression will be higher for a given pressure than in a gas engine. This results in a high temperature throughout the cycle, so that more heat units are lost through the cylinder than would be the case if the charge entered the cylinder at atmospheric temperature. These conditions entail a secondary disadvantage, namely, an early limit to the compression ratio on account of the increased liability to premature ignition by reason of the higher working temperatures, and the lower igniting point of oil vapor as compared with coal gas.

In addition to the irregularity and imperfect combustion, low explosion pressure characterizes the "pump and vaporizer" class of liquid fuel engines. This means that for a given size of cylinder and quality of fuel the mean effective pressure (and consequently the power) will be considerably lower. In some engines the M. E. P. is actually lower than the air compression. The full load diagram in one oil engine with a compression of 65 pounds showed a M. E. P. of 29 pounds. This, of course, results in increasing the size of the engine in proportion to the power developed.

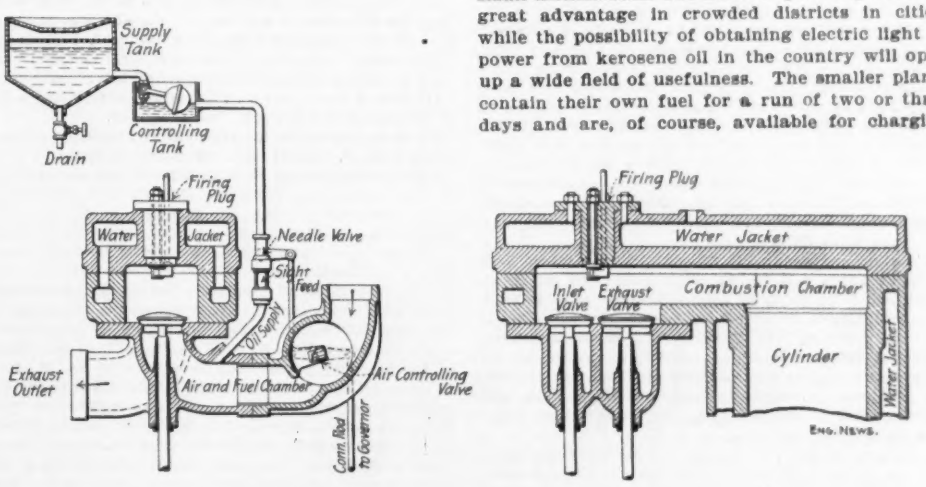
In view of all these considerations it was considered desirable, if possible, to dispense entirely with vaporizers and force pump regulation. A series of experiments demonstrated that gravity from a constant head or pressure combined with micrometric measuring devices would furnish the requisite element of certainty in an oil feed. It was found further that a certain definite temperature could be relied upon to produce gasification within the cylinder itself. The great advance achieved in fuel flexibility is obvious. There is also a marked advance in the quality of combustion over engines using vaporizers. The fuel enters with the air, both being at normal temperature through the main admission valve; as the system demands absolutely correct proportions and a homogeneous mixture of air and fuel it became necessary to employ a micrometric system of adjustment by which the necessary relation could be maintained. In its final development the Secor system permits the same engine to use either gaseous or liquid fuel. The quality and form of the fuel determines the size of the fuel valve. For liquid fuel a small needle valve is used, while for gas a valve similar to the air valve, but slightly smaller, is employed. The governing is effected by varying the quantity of mixture to suit the load. The engine responds to changes of load as rapidly as a high speed steam engine maintaining absolute steadiness under sudden and extreme changes.



Side Elevation. Vertical Section.

FIG. 2.—SECTIONAL ELEVATIONS OF SECOR ENGINE.

When liquid fuel is used the oil is supplied to the engine by gravity from a small oil cup, where, as previously stated, the oil is kept at a constant level. The quantity is determined by the needle feed valve, which is controlled by the governor and which is operated simultaneously with the air valve. The fuel oil cup is supplied from the main reservoir by pumping or gravity as desired.



Part Transverse Section. Part Longitudinal Section.

FIG. 3.—SECTIONS SHOWING ARRANGEMENT OF ADMISSION AND EXHAUST VALVES WITH FUEL REGULATING ARRANGEMENTS OF SECOR ENGINE.

In designing the Secor engine it was believed that the upright, open form of stationary steam engine now commonly known as the "marine type," offered the maximum of strength with the minimum of weight, this form was adopted for engines of medium and large size. One advantage resulting was the ability to reduce the gross weight about one-half, while adding about one-third to the strength of the cylinder and about 50% to the crank shaft. The upright form occupies less floor space and permits a better distribution of weight on the foundation than is possible with the horizontal engine. The wear on the cylinder from piston friction is less. The influence of the foundation in the suppression of vibrations also appears to be more efficient. The open type is easier to examine, to clean and to adjust than the enclosed type, thereby adding greatly to the durability of the engine. It was desired to simplify the mechanical details of the engine as far as practicable, also to provide compensation for inevitable wear wherever it was possible to do so. The general idea has been to avoid complication, to retain a high factor of safety by making all parts amply strong and to have the mechanism in all its parts easily accessible to the operator. Having this in view, the design renders it possible by the removal of a single casting to expose the interior without disturbing any working part of the engine.

Although the mechanism is simple, four results of supreme importance are accomplished:

(1) Reliability is maintained by a method which furnishes the requisite conditions with unvarying regularity.

(2) Perfect speed regulation under varying load is assured by the precision due to micrometric adjustment coupled with rapidity of action.

(3) Colorless combustion under varying load is obtained by automatically satisfying the chemical requirements of correct proportions and homogeneous mixture.

(4) Fuel flexibility is obtained by adopting an interchangeable method of fuel supply which does not depend on pumps or vaporizers.

These engines combine thermodynamic with mechanical efficiency, the latter averaging 85%. The compression varies somewhat with the size and type of engine; it ranges from as low as two atmospheres up to five atmospheres. The cylinder diagram herewith shown, from an engine 16 ins. diameter by 15 ins. stroke, with throttled charge, shows low compression with high M. E. P. These engines are now being manufactured in various forms and sizes and are available for all purposes where a stationary steam engine could be employed.

In combination with a direct-connected dynamo these motors make a complete self-contained electric installation well adapted for medium sized or small installations. The limited space required is a great advantage in crowded districts in cities, while the possibility of obtaining electric light or power from kerosene oil in the country will open up a wide field of usefulness. The smaller plants contain their own fuel for a run of two or three days and are, of course, available for charging electric launches and carriages. The E. M. F. from a single cylinder plant of this character is absolutely steady.

Where it is desirable to distribute power in various units through a factory these engines are especially desirable, as each department or group of machines can be furnished with an engine, all machines being operated by a single attendant, who need not be a licensed engineer.

Recent developments in the design and construction of gas producer plants suggest the application of gas engines to street and interurban

railway service to an extent that would have been called visionary five years ago. The high price commanded by coal in many quarters forces into prominence the problem of cheap power. In view of the various advantages which the gas engine possesses over the steam engine, it would seem as if the larger metropolitan power houses for street railway service must eventually come to the point of adopting the new system, as the cost of fuel per electric horse power hour would under such conditions undoubtedly fall to less than one-third the present figure. The necessity for strict economy in the matter of land is another very strong factor in the case, and one which is coming to have more and more weight every year.

The Secor engine is now being manufactured by the General Power Company, 100 William St., New York City.

AN EXPERIMENT WITH WET AND DRY CONCRETE.*

By Irving Hitz.†

There is at present a wide diversity of opinion among what are supposed to be our best authorities, as to the amount of water that should be used in mixing concrete. The authors on this subject disagree radically, and the engineers and building contractors are similarly divided in practice. In view of this great difference of opinion on this subject, and with the idea of confirming, or perhaps changing, its present practice, the bridge and building department of the Chicago, Milwaukee & St. Paul Ry. conducted the following experiment:

Two boxes, each 3 ft. square at the base and 3 ft. high, were carefully made of matched and surfaced 2-in. timber, as nearly alike as possible. They were then balanced 13 ft. apart, c. to c., on two 8 × 16 ft. bridge stringers, with a short piece of rail on the under side of each stringer, and a third piece of rail placed across and under the other two at the central point between the two cubical boxes, on which the whole structure rested. The boxes were then made to balance while empty, by adding weights to the light end, and all was in readiness to receive the concrete which was to be placed in them. In one box was placed a very wet mixture and in the other a dry mixture.

The concrete was made of 1 part of Atlas Portland cement, 3.24 parts of gravel, and 3.65 parts of crushed limestone. The gravel used was composed of 51% of sand which would pass through a No. 4 screen, and 49% of pebbles ranging in size from ¼-in. to 3 ins. in diameter. This made the actual proportions about 1 of cement, 2 of sand, and 5 of crushed stone and pebbles. The concrete was mixed by a Ransome concrete mixer, and all the materials used were carefully measured.

In the box containing the wet mixture was placed 4.38 cu. ft. of water, 5.35 cu. ft. of cement, 17.32 cu. ft. of gravel, 19.5 cu. ft. of crushed stone—a total of 46.55 cu. ft., and the box held exactly 27 cu. ft., making a reduction of volume due to voids in stone and gravel of 40%. The 4.38 cu. ft. of water added is 82% of the volume of the cement used and made a concrete which was very wet, sloppy and awkward to handle, as the wheelbarrows would hold only a limited amount without slopping over. When deposited in the box it required no tamping and, when allowed to stand, water would come to the surface. It was purposely given a greater excess of water than would ever be used in actual practice. A part of this excess water escaped through the cracks and over the top edge of the box when filled.

In the box containing the dry mixture was placed 2.05 cu. ft. of water, 4.71 cu. ft. of cement, 15.25 cu. ft. of gravel, and 17.16 cu. ft. of crushed stone—a total of 39.17 cu. ft., making a reduction of volume due to voids in stone and gravel of 31%. The 2.05 ft. of water which was added was 44% of the volume, or 34% of the weight, of the cement used, and made a mixture which, by repeated very hard tampering could be made to quake slightly, and moisture could be seen on the surface of each 6-in. layer after the tamping was done.

It required 35 mins. to fill the box with the dry mixture and 20 mins. to fill the box with the wet concrete; the difference in time being due to the amount of tamping required to properly compact the dry mixture.

As soon as the boxes were filled the blocking was removed so that the weight of the cubes rested on the cross rail, and by means of the jack screw under one end this rail was shifted until the two cubes exactly balanced. It was found necessary to move the center cross rail 0.30 ft. toward the cube of wet concrete to effect a balance. This showed that the wet concrete cube weighed 9.7% more than the cube of concrete which had been mixed dry; a difference of about 340 lbs.

When the concrete had set and the frame was removed the difference in the appearance was very apparent. The face of the cube of wet concrete was smooth and compact, while that of the dry cube was full of voids and very rough, notwithstanding the fact that much more time and labor were expended in tamping and depositing in layers the concrete of the dry mixture.

The cubes were allowed to stand on the balance 30 days. Careful observations were taken to see if the loss of the excess water in the cube of wet concrete would appreciably diminish its weight, but no such loss of weight could be observed.

When the cubes were 30 days old they were broken in the following manner: Five ¾-in. holes were drilled about 6 ins. deep across the center of the top surface, and two similar holes were placed down the sides. Ordinary plugs and feathers were then used to crack open the cubes. The same number of holes were used for both cubes, and it was found that the cube of wet concrete was very much harder to break than the other; and the cube of dry concrete broke vertically down to the center of the cube and then the fracture followed the horizontal layer which marked the top of the first batch deposited by the mixing machine. The Ransome mixer contains, when full, about ½ cu. yd., and there was, therefore, an interval of about five minutes after the first one-half of the box was filled until the rest was put in. This second batch did not make a perfect union with the first one in the case of the dry concrete, and the cube broke along this line which marked the top of the first batch, at first, and had to be redrilled and broken to get the lower half in two parts.

The interior of the wet cube was a solid and compact mass, with most of the pieces of limestone and granite pebbles broken across along the line of the fractured cube; while the interior of the cube of dry-mixed concrete was full of voids and pores, and a much larger percentage of

View Showing Comparative Smoothness of Wet Concrete and Dry Concrete Cubes.

the pieces of stone and pebbles were pulled out of the opposite side of the fracture, instead of being broken as they were in the wet mixture.

This experiment was conducted at 5 p. m. on a warm day, the thermometer reading 80° F., which accounts in part for the large percentage of water used, even in the dry mixture. The results of this test seem to show:

(1) A moderate excess of water is not injurious.

(2) More labor is necessary in mixing and placing a dry or moderately dry concrete than a wet one.

(3) It is impossible to get a compact concrete without using what is, theoretically, an excess of water.

I believe the practice of using dry concrete to the extent it is used at present has arisen from the fact that laboratory experiments, which are generally conducted on a small scale, under quite different circumstances from the conditions of actual practice, have shown the best results with a minimum amount of water. The objection that is often raised that an excess of incompressible water must leave voids in the concrete upon evaporation, is not a serious one. The excess of water would not, in actual practice, ever exceed 1 cu. ft. in 27 cu. ft., and, as was shown by the foregoing experiment, there were 2½ cu. ft. more of voids in the cube of dry mixed concrete than in the one containing an excess of water. On exactly the same principle that a hole excavated in the earth can be refilled much more compactly and permanently by the addition of water to the filling than by any amount of tamping of dry or moist earth, so can a more compact concrete be made by the use of a slight excess of water.

DISCUSSION.

Mr. E. H. Lee.—The general trend of practical work seems to be toward quite a wet mixture, and mainly for the reason brought out in the paper that, unquestionably, the wet mixture tamps itself, as it were. The question of tamping, everyone will concede, is a very important one in making concrete, and while, theoretically, a concrete which is relatively quite dry ought to be, and, perhaps, with sufficient attention can be, properly looked after, and sufficient tamping secured, yet, as a matter of fact, in practical operation it is almost impossible to secure proper tamping in anything like what might be called a very dry mixture. And this practical consideration would seem to me to be worthy of more weight than all of the laboratory tests, which seem to point in the other direction, toward a moderately dry mixture. As to the question of whether a mixture can be too wet for practical purposes, it would seem as if the fact that concrete is successfully used under water, and, when put in under proper conditions develops at least an equal, if not a greater, strength than in air, should be a final answer to that question.

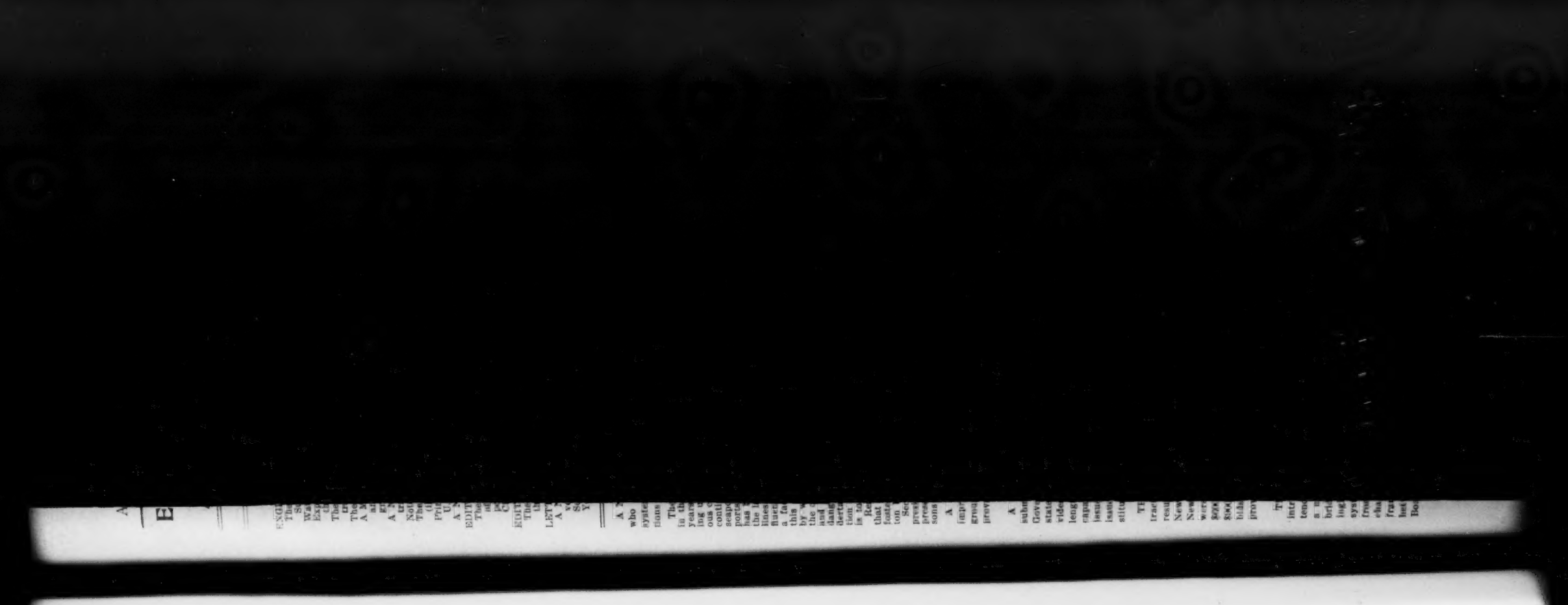
Mr. H. P. Boardman.—I have heard and read a good deal about the results of laboratory experiments differing from the results of these practical experiments in that the dry mixtures give a much stronger mortar than the wet mixtures. But I have never been able to get such results in my experience with laboratory experiments, and I have made a great many tests, varying the per cent. of water, for instance, for neat Portland cement from 11 or 12% to 30 and 32%; but the one thing I always insisted on was that the mortar, in every consistency, be put into the molds by thumb pressure, and not pounded in. I never considered that a dry mortar pounded into the molds could give a fair test of the strength. Very dry cement mortar can be pounded into molds and a very strong briquette made, but you never get that condition in practice. The hardest tamping you can give the concrete in work, when you consider its effect on the concrete, must be very slight compared with what you get in a briquette, where you have such a small quantity closely confined in a mold upon which to concentrate the tamping. Now, wet mixtures can be compacted no more by pounding than by thumb pressure, because when you press the mixture in one place it yields in another, and the results of the experiments I have made in that line almost invariably show that the strongest mixture and the one that gives the most dense mortar is wet enough to be plastic, so that it can be readily molded into any shape. When you press in one part of the mold it yields in another place. That is the general conclusion, both for a natural cement and Portland cement, sand mortar and neat mortar.

In this connection, it may be well to cite the experiments of Mr. Rafter on concrete cubes. He argues that the dry mixture is stronger, and his experiments seem to show that it is slightly stronger in compressive strength. He had three mixtures—the dry, the plastic and the excess. He made a great many 12-in. cubes and they were broken at the Watertown arsenal. The dry mixtures averaged a very little the strongest. But any one of them is so much stronger than is demanded in practice in the ordinary use of concrete, that I don't think the actual strength in compression, as determined by these experiments, should cut very much figure in deciding which to use, when the cost of getting good, dry concrete is so much more than for wet—on account of the difficulty in tamping the dry.

Mr. G. A. M. Liljencrantz.—From the fact that one of those blocks broke horizontally, caused by an interruption in the work of only some four or five minutes, indictates the importance of an uninterrupted supply of material throughout the construction of an excessive mass, as, for example, one of the locks on the Illinois and Mississippi Canal, where the whole lock chamber is a concrete monolith.

Mr. Lee.—In the work with which I happen to be connected on a sanitary district, we used a very wet mixture. The view of the engineers in charge, as near as I was able to get at it, was that the wetter the better. There was no special reason why they should attempt to avoid shrinkage cracks, no special damage being possible on account of their presence. In that wall, I may say that there was no special provision made for lines of weakness in the concrete wall, in order that, should shrinkage develop cracks, they would come in special places. It seems to be a growing practice to provide mechanically, so that when the cracks develop, as they seem bound to do in long walls, they may come at a special place and, as nearly as possible, form a vertical line. In much of the wall that has been recently constructed it will be found that a line of weakness has been provided for by bulkheading the wall every 40 to 60 ft. of its length. Sometimes a triangular strip is nailed to the face of the form and the bulkhead is brought to the center of that strip, in order to form a joint when the concrete is placed. This seems desirable, because the recess in the face of the concrete hides the crack or at least conceals its apparent effect, as pointing up masonry does so much to decrease the apparent thickness of the joints. When the 16th St. crossing work was begun, several walls were constructed without the introduction of bulkheads, but it was noticed that large cracks developed, the reason for these cracks being, in great part, the unequal settlement of the ground on account of unequal loading; not on account of the expansion and contraction. But their presence was very unsightly, and later the bulkheads were introduced, in order to form a line of weakness where these cracks would develop. The engineer had a V-shaped joint at these lines of weakness chiseled out. The joints show plainly, but it has had in large measure the effect of concealing the cracks.

Mr. E. R. Shnable.—I am able to testify as to the effect of very wet mixtures. We built a wall in Joliet, 4 ft. wide on top, 6½ to 8 ft. wide on the bottom, and about 14 ft. high. The inspectors insisted on a mixture practically as wet as slop. The pitmen, while spreading this mixture, would almost sink to their knees. This wall was completed more than a year ago, and no expansion and contraction cracks have developed as yet. In a few places the 3-in. Portland cement mortar has slightly lifted or blistered up. The wall is about 2,500 ft. long and was built in 100-ft. sections by three gangs.

*Abstract of a paper read before the Western Society of Engineers, Oct. 17, 1900.

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